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Abstract

The construction industry has great environmental impacts and it accounts to 39% of all of the world's carbon emissions. Of these, the operational emissions, such as the energy to heat and light buildings, account for 28%, whereas the remaining 11% is associated with construction processes and materials throughout the lifecycle of the building. These impacts with the identified increased competitive advantage are pushing the companies in the construction industry to find ways to improve their environmental sustainability. In the construction industry supplier relationships are an important part of the business since 60-80% of all of the construction project's costs come from purchases.

This research aims to provide the case company, as well as other similar companies in the industry, methods to improve their environmental sustainability. This subject is looked at with the focus on supplier collaboration since it holds an especially significant place in the construction industry.

The study uses green supply chain management and sustainability collaboration as the background for the theoretical framework. The study was conducted by interviewing a case company and its six suppliers. These six suppliers were picked due to their pioneer status in environmental sustainability in the Finnish construction industry. The study found different ways a construction company can improve their environmental sustainability, and that collaboration is a key element in achieving environmental objectives. These ways are setting sustainability objectives for the company, applying sustainability as a company value or to seek competitive advantage, implementing certified systems, practicing supplier supervision, finding eco-friendly production solutions, investing in product development, implementing personnel training, practicing recycling, finding eco-friendly logistic solutions, collaborating with stakeholders, implementing projects that improve environmental sustainability but that are not directly linked to company's processes.

Key words	Green supply chain management, construction industry, environmental sustainability, sustainability collaboration
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Tiivistelmä

Rakennusalalla on suuret ympäristövaikutukset, ja niiden osuus maailman kaikista hiilidioksidipäästöistä on 39 %. Näistä operatiiviset päästöt, kuten rakennuksiin tarvittava lämpö- ja valoenergia, aiheuttavat 28 % päästöistä, kun taas loput 11 % liittyvät rakennusprosesseihin ja materiaaleihin rakennuksen koko elinkaarelta. Nämä vaikutukset ja havaittu lisääntynyt kilpailuetu pakottavat rakennusteollisuuden yrityksiä etsimään tapoja parantaa ympäristövastuullisuutta. Rakennusteollisuudessa toimittajasuhteet ovat tärkeä osa liiketoimintaa, koska 60–80 % kaikista rakennushankkeen kustannuksista tulee hankinnoista.

Tämän tutkimuksen tarkoituksena on tarjota caseyritykselle ja muille alan vastaaville yrityksille menetelmiä ympäristövastuullisuuden parantamiseksi. Tätä aihetta tarkastellaan keskityen toimittajien yhteistyöhön, koska sillä on erityisen merkittävä asema rakennusalalla.

Tutkimuksessa käytetään vihreän toimitusketjun hallintaa ja kestäväen kehityksen yhteistyötä taustana teoreettiselle viitekehykselle. Tutkimus tehtiin haastattelemalla caseyritystä ja sen kuutta toimittajaa. Nämä kuusi toimittajaa valittiin johtuen pioneeriasemastaan ympäristöasioissa Suomen rakennusteollisuudessa. Tutkimuksessa löydettiin erilaisia tapoja, joilla rakennusyhtiö voi parantaa ympäristövastuullisuutta, ja että yhteistyö on avaintekijä ympäristötavoitteiden saavuttamisessa. Nämä tavat ovat vastuullisuustavoitteiden asettaminen, soveltaa kestävää kehitystä yrityksen arvona tai kilpailuetuna, sertifioitujen järjestelmien implementointi, toimittajien valvonta, ympäristöystävälliset tuotantoratkaisut, tuotekehitys, henkilöstön koulutus, kierrätys, ympäristöystävällisten logististen ratkaisujen löytäminen, yhteistyö sidosryhmien kanssa ja muiden hankkeiden toteuttaminen.

Avainsanat	Vihreä toimitusketjujen johtaminen, rakennusala, ympäristövastuullisuus, vastuullisuusyhteistyö
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**UNIVERSITY
OF TURKU**

Turku School of
Economics

**IMPROVING ENVIRONMENTAL
SUSTAINABILITY IN CONSTRUCTION:
SUPPLIER COLLABORATION APPROACH**

Master's Thesis
in Operations and Supply Chain Manage-
ment

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The originality of this thesis has been checked in accordance with the University of Turku quality assurance system using the Turnitin OriginalityCheck service.

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LIST OF ABBREVIATIONS

CDP	Carbon disclosure project
CE	Circular economy
CMS	Carbon management strategy
CPO	Chief purchasing officer
CSR	Corporate social responsibility
C&D	Construction and demolition
ECD	Environmentally conscious design
EHS	Environment, Health and Safety
EP	Environmental Performance
EPD	Environmental Product Declaration
EPS	Expanded polystyrene
EWG	European Waste Codes
FSC	Forest Stewardship Council
GHRM	Green human resource management
GIC	Green innovation culture
GSC	Green supply chain
GrSCM	Green supply chain management
GSCM	Green supply chain management
HVAC	Heating, ventilation, and air conditioning
LCA	Life-cycle assessment
PEFC	Programme for the Endorsement of Forest Certification
ROA	Return on assets
SC	Supply chain
SCI	Supply chain integration
SDS	Supplier development for sustainability
SRM	Supplier relationship management
SSC	Sustainable supply chain
SSCM	Sustainable supply chain management
VMI	Vendor managed inventory
VOC	Volatile organic compound
WtE	Waste-to-energy
ZEB	Zero Energy/Emission Building
ZEN	Zero Energy/Emission Neighborhood

1 INTRODUCTION

According to the World Green Building Council (2019) 39% of all of world's carbon emissions come from building and construction. The operational emissions, such as the energy to heat and light buildings, account for 28%, whereas the remaining 11% is associated with construction processes and materials throughout the lifecycle of the building. The base for sustainable construction is stated in law, such as the environmental protection law, which was last updated in 2014 (Finlex 527/2014). Companies are now aiming to go above the regulated level in sustainability matters. Leading construction companies are taking responsibility for their environmental impacts by putting green initiatives in their value proposition and they have already started to challenge and educate their suppliers and clients in order to win competitive advantage and to achieve the broadest possible sustainability benefits while executing construction projects (Berry & McCarthy 2011, 8).

1.1 Research questions

The environmental impact of the construction industry is vast and the companies in this industry need tools to tackle these impacts. The goal of this study is to find the mechanisms a construction company can use to decrease their environmental impact. This goal is the base for the first research question (RQ1) of this study, which is:

RQ1: What mechanisms can a construction company use to improve its environmental sustainability?

In existing literature, Green supply chain management (GSCM) offers companies in all industries basic principles to implement green initiatives to the company's processes. GSCM can be defined "as integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life" and it can be divided into green design and green operations (Srivastava 2007, 55).

In the construction industry the percentage of purchases has been increasing continuously, and the proportion of material purchases and subcontracts in the total cost of a construction project is typically around 60-80%. Since the meaning of the purchases has

increased significantly, purchasing has evolved from the simple operation of buying materials and services to cooperation with subcontractors and material suppliers. (Junnonen & Kankainen 2012, 5.) This means that the environmental impact load should be tackled upstream of supply chain where 2/3 of the total load is being generated. The importance of the purchases and therefore supplier collaboration brings another dimension for this research, and another research question (RQ2), which is:

RQ2: What are the ways that a construction company can improve its environmental sustainability by collaborating with its suppliers?

The impacts of the company's supply chain on sustainability should be considered and sustainability practices should be extended to the suppliers. Collaboration with suppliers is hence key factor in improving environmental performance. (Gimenez & Sierra 2013, 189, 197.) Vachon and Klassen (2008, 309) define environmental collaboration as "encompassing joint environmental planning activities and cooperation in finding solutions to environmental challenges". Since the role of the suppliers is exceptionally significant in the construction industry, this research will also look at environmental collaboration and focus on the suppliers by reviewing supplier relationship management, to find the ways that a construction company can effectively tackle its environmental impacts.

Sustainability is generally divided into three pillars: social, environmental, and economic sustainability (Azapagic & Perdan 2000, 244). Due to the broadness of the subject and the major environmental impacts of the construction industry, this study will focus solely on environmental sustainability.

1.2 Research methods and structure

This research aims to find answers to the research questions using a qualitative research approach and uses a case company. The case company is a large Finnish construction company with three subsidiaries in different areas of Finland. The empirical data consists of a total of seven interviews, of which one interview is with the case company, and another six interviews with its suppliers. The supplier companies were picked by the case company due to their pioneer nature concerning environmental sustainability.

To know about the current GSCM principles this research starts by reviewing GSCM literature in chapter 2, and then looking at the topic from the construction industry's point of view, as well as dividing the subject to green design and green operations. Chapter 2

provides information mainly for RQ1, as well as some basic knowledge for RQ2. Chapter 3 focuses on providing information to RQ2 and takes a look at how supplier relationship management and environmental collaboration can offer companies tools to achieve their sustainability objectives more effectively. Chapter 4 combines chapters 2 and 3, positioning the research questions in current literature and highlighting possible GSCM mechanisms that construction companies could and should use to improve their environmental sustainability. Chapter 4 presents these GSCM mechanisms as a theoretical framework, against which the interviews are later looked at. Chapter 5 explains the method choices for the study and introduces the empirical data. Chapter 6 goes over the empirical data and chapter 7 brings the results together with the theoretical framework. Finally, the study is concluded in chapter 8.

2 GREEN SUPPLY CHAIN MANAGEMENT IN CONSTRUCTION

2.1 Green supply chain management

GSCM can reduce the environmental impact of industrial activity, and this can be done without sacrificing cost, quality, performance, reliability, or the efficiency of energy utilization. GSCM research is generally linked to the content area of operations strategy, such as supply-chain management, quality and product and process technologies. (Srivastava 2007, 68.)

Figure 1 is made by Srivastava in 2007 about the researched areas of GSCM, or GrSCM, as Srivastava abbreviates it. Importance of GrSCM refers to literature focusing on the importance and necessity of GSCM. Green design is one of the parts of GSCM. Green design consists of two elements: ECD (environmentally conscious design) and LCA (lifecycle assessment). (Srivastava 2007, 57-58.)

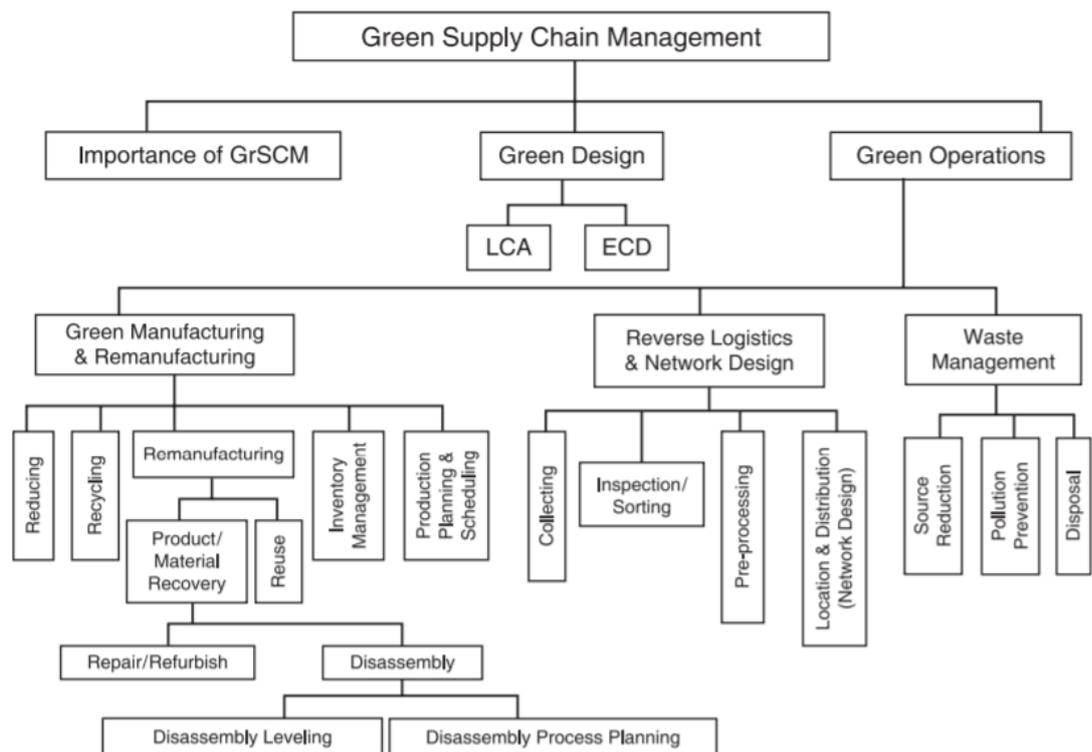


Figure 1 Classification based on problem context in supply chain design (Srivastava 2007, 57)

GSCM includes alternative methods to improve environmental sustainability, such as green manufacturing and remanufacturing, waste management, and reverse logistics. Green manufacturing and remanufacturing include operations such as reducing the use of virgin materials, recycling, remanufacturing, inventory management, and production planning. Reverse logistics include the collection, inspection and sorting, pre-processing, and distribution of the product. The third operation of GSCM is waste management, which includes source reduction, pollution prevention, and disposal. Source reduction and pollution prevention focus on limiting the amount of pollution at the source. (Srivastava 2007, 59-62.)

GSCM focuses on low environmental consequences in addition to efficiency, cost, and high customer service (Achillas et al. 2019, 3). Applying GSCM policies into the existing supply chain is an extensive project with many steps. Switching to GSCM requires a paradigm shift in order to minimize ecological damage but at the same time achieving economic profit (Srivastava 2007, 68). Achillas et al. (2019, 2) present the following matters to take into consideration when implementing GSC policies:

The integrated planning of the green supply chain requires the management of a business or organization to initially determine the inputs, drivers and enablers that must be processed for the production, transportation and distribution, packaging and recycling of green products. - - The management of green supply includes the planning, execution, monitoring and control of practices, approaches and tools that assists organizations of their “greening” process to become socially responsible and sustainable through environmental protection.

Adopting green practices has a high initial cost, which may be a reason why some companies avoid starting the process. This high initial cost is however compensated in the long run with savings that consist of reduced energy consumption, recovering materials by recycling and reduced waste treatment cost. Adopting GSC policies also lead to an improved company image. (Engin et al. 2019, 5.)

Applying GSC practices includes the critical matter of identifying the key stakeholders that are connected to the GSC initiatives. In sustainable supply chain management, the idea of sustainability is brought from a company level to the supply chain level, which means that SSCM and GSC are often discussing the same matters. Important principles

in SSCM include transparency, accountability, and stakeholder engagement. Main issues of GSCM are:

- procurement-sourcing, warehousing, manufacturing & re-manufacturing, SC network design, waste management
- achieving cooperation, coordination, and integration of the SC partners of the SC, and improving communication
- supporting the process of decision-making on the operational, tactical and strategic levels

These practices will help to achieve the optimization, automation, simplification, and re-design of GSCM processes. (Achillas et al. 2019, 2-3.)

Conaway and Laasch (2012, 4, 85) remark that vision and mission statements, as well as code of conduct are critical for company's sustainability performance. They also explain that a company needs to first make social and environmental contributions, and then communicate this progress in order to be viewed positively by stakeholders and consequently gain financially.

Research encourages the adoption of management certificates, such as the ISO14001 environmental management system. Arocena et al. (2021, 964) found that ISO14001 environmental management system helps companies to reduce carbon emissions and increases profitability as well. A study linking ISO14001 and operating performance by Treacy et al. (2019) found that the adoption of the ISO14001 leads to a greater ROA (return on assets) by more efficient use of company's physical assets, improved workforce productivity, greater operating efficiency, and lower manufacturing costs as well as a shorter operating cycle. Sustainability performance is also affected by the maturity of the integration of these management systems (Poltonieri et al. 2019, 244).

Firms are implementing carbon management strategies (CMS) because of regulatory factors and because of stakeholder expectations (Yunus et al. 2020, 1206). These strategy types are compensation, reduction, and carbon independence. In carbon compensation, companies do not change their processes, but compensate their carbon usage by either acquiring additional CO₂ capacity or by investing in projects that compensate their carbon emission creation. In carbon reduction, companies find ways to decrease their emissions by improving their current production processes, or by creating a product that requires less energy during production. Carbon independence means using production processes that are carbon free and designing products that are carbon free. A company can and often will use many of these strategies simultaneously. (Weinhofer & Hoffman 2010, 80, 85.)

Teaching the personnel to think green helps the company to achieve its sustainability targets faster. Muisyo and Qin (2021, 9) found that green human resource management (GHRM) leads to a better environmental performance (EP). They also remarked that firms that implement GHRM policies should consider green innovation (GIC) culture as well, which is essential as it helps the personnel support the implementation of green strategies and accomplish higher EP.

Mahapatra et al. (2021, 10) remark in their article that companies are voluntarily participating in the carbon disclosure project (CDP) and are actively publishing sustainability reports, which indicates that companies are actively trying to become green. Mahapatra et al. then analysed the CDP data and found that there is a mismatch between reported carbon reduction efforts made by companies and actual carbon emission reductions, and that significant positive environmental outcomes cannot yet be seen.

2.2 Green procurement

Green procurement is an important part of GSCM, since the value of purchases is often significant within companies. Green procurement is “the implementation of green practices in the process of procurements.” This includes low-energy storage and distribution, products made from non-toxic and recycled materials and monitoring factors that affect negatively the life cycle of the service or product. This means that green procurements seek products with no environmental or social effect. Green products or services have one or more green practices implemented in their life cycle for the minimization of CO₂ emission, reduction of water consumption and water pollution, diminishing the effect of toxic chemicals and the reduction of the unrestrained consumption of raw materials. (Achillas et al. 2019, 38-40.) Green procurement requires additional effort because of the changes in the supply chain. For example, unfamiliar product lead times and subcontractor training are risks that the use of new products include. (Kibert 2016.)

The selection criteria of suitable suppliers include matters such as price, reliability, and the supplier’s reputation. In green procurement social and environmental criteria should also be added. The concept of lean production is connected to green procurement, in the sense that green procurement means the purchasing of products that are really needed. Implementing these green procurement practices requires also a change in attitude. Executives, employees, and business partners of a company should adopt a mentality with a respect towards procurements. (Achillas et al. 2019, 40.)

Green procurement involves both sides of the procurement process, suppliers and customers. The focus is not on the operative side of procurement, such as the placing of orders, but rather in the acquisition process of products and services. Green procurement is related to strategic sourcing, which is a broader and more transformational process which is conducted at a strategic level. Strategic sourcing examines the entire supply network, with the focus in value creation, risk management, overall resilience and responsiveness of the supply chain, and the optimization and management of supplier alliances and relationships. (Achillas et al. 2019, 40-41.) Green product procurement in construction may lead to the need of using different suppliers than is usual for a company, meaning that new supplier relationships may need establishing (Kibert 2016, 476).

2.3 Green construction

Many contractors have taken a passive role in regard to sustainability in construction during the previous years. Green construction has been quite client-led, with contractors adopting sustainable solutions only when asked for them. (Berry & McCarthy 2011, 8.) The construction industry has now however realized that sustainability and green building are important selling points in both the home and b2b market, and this is causing an increasing number of builders, designers and building owners engaging in green building practices. (Kubba 2017, 55.) Leading contractors are taking responsibility for their impacts, in such ways as setting their own standards in their value proposition, challenging and educating their main suppliers and/or clients to win competitive advantage, delivering new sustainable solutions and promoting sustainability in the whole supply chain by cooperating with their main suppliers, and aiming to provide the broadest possible sustainability benefits while undertaking construction projects. (Berry & McCarthy 2011, 8.)

Practicing sustainability and green building means the incorporation of eco-friendly techniques and sustainable processes into the operations of a company (Kubba 2017, 55). Green building has many positive outcomes. For example, the incorporation of green strategies during the design phase is a good way to increase project's market value. An energy efficient building also decreases energy costs significantly when the building is in use. In addition to these assets, green buildings can also provide occupants and tenants with a healthier working environment because of improved indoor air quality. This is the result of green building not using materials that may contain high volatile organic compound (VOC) emissions and asbestos, lead and formaldehydes. (Kubba 2012, 22-23.) Whether a building is considered green depends on many issues, and there are numerous

building rating systems around the world. In general, the following matters should be evaluated and considered, when evaluating how green a building is:

- sustainable site planning
- design that minimizes environmental impact
- design that incorporates energy-efficient lighting, HVAC, electrical and water heating systems
- the use of renewable energy sources to generate energy onsite
- water efficiency
- waste management
- use of sustainable products and materials that have high recycled content, have minimum releasing of harmful chemicals, and are rapidly renewable
- quality of indoor environment, for example thermal and visual comfort and indoor air quality (Kubba 2012, 67-68.)

Construction companies should design and build buildings that use natural or recycled materials in their construction and that are energy efficient when building in a green and sustainable way. Green building means operating more efficient than conventional building in the use of resources such as water, energy, and land. (Kubba 2012, 22.)

Even though nowadays there are multiple green building rating systems such as LEED, Green Globes and BREEAM, the recognition for the need for sustainability criteria was introduced as early as 1983 with the formation of World Commission on Environment and Development, created by the United Nations. These ratings systems following in its footsteps aim to define both the qualitative and the quantitative measures for sustainability, including the data that is needed for the implementation and assessing of these measures. This criterion helps evaluate the impact a building has on the environment and human health. (Kubba 2017, 27.)

An article by Murano et al. (2020, 11-12) analyzes the relationship between the built environment and circular economy in research literature. Thematically, most articles, 39%, are about recycled and reusable materials. Topics covered in this theme include the practice for C&D waste management while looking at the entire value chain for improved resource efficiency as well as the reduction of environmental impact. 22% of articles concern the transition towards the principles of circular economy, such as the development of sustainable services. The last three themes, covering 17%, 14% and 8%, respectively,

are assessment and tools for the support of circular buildings, building and product design and stock and flow analyses concerning materials and resources.

2.3.1 Green design

The environmental friendliness of wood building versus concrete building is under debate in Finland (Talouselämä 2020). According to a study conducted by Gustafsson et al. (2020, 688) compared the lifecycle emissions of wood and concrete frames in Finland and Sweden. They found that a net reduction of carbon emissions can be achieved by increasing the use of wood as a construction material, since the production of wood material requires less energy than concrete, but also with construction and demolition. A study by Rebane and Reihan (2016, 736) found that the use of timber as a building material leads to lower embodied energy amounts.

Zero energy buildings are a new concept in construction industry. A review made by Andersen (2017, 69) found that it is technically possible for most building types to reach a zero energy building (ZEB) balance. A ZEB does include a higher cost for construction and design, but the outcomes can be predicted quite accurately with current technologies and strategies. ZEBs are generally newly-builds, but old buildings can be also renovated as ZEBs. Andersen predicts a widespread market penetration for ZEBs in the next few years due to the continuous decrease in costs and technology development. Andersen even talks about the possibility of Zero Emission Neighborhoods (ZEN).

2.3.2 Green operations

A construction project often starts with the demolition of a previous structure. Before demolition, there should be an inventory of materials that can be used in the new structure and hence should be salvaged. This is called a materials audit. These materials are for example doors, windows, and brick. If the collected materials cannot be used in the structure, there is still a possibility of recycling. This requires establishing areas for recycling, scrap storage, cutting areas and disposal on the construction site. This type of arrangement diverts demolition materials from landfills. Another way to handle demolition waste is to use it as an on-site fill. Materials like brick and concrete can be crushed and then used as a subbase. (Kibert 2016, 480.)

A way to practice green construction is to improve waste management. Construction of buildings produced 2 million tons of waste in 2016. In comparison, service industry

and households produced 3 million tons of waste. In 2020, the goal in Finland is to recycle 70% of construction waste. (Confederation of Finnish Construction Industries RT.) Manufacturing building components on-site generates a great amount of construction scrap. This kind of scrap material is more likely to get recycled in an off-site shop than on the construction site. This means that manufacturing building components off-site reduces non-recycled waste. Another way to decrease waste is to purchase materials in bulk to avoid extra packaging waste. However, procurement should be accurate, so that there is no excess materials and products on-site. One possibility to deal with excess material would be for the manufacturer to buy it back and restock them, provided that the materials have been protected and that they are not customized. (Kibert 2016, 479-480.)

A key factor in a sustainable construction project is proper coordination with the numerous subcontractors. This helps with waste separation, proper materials handling, and identifying the scope of work. Clear communication helps in preventing potential rework and damage to installed systems. In addition to generating waste, rework also extends the completion schedule and increases project cost. (Kibert 2016, 480.) Efficient planning is essential when it comes to implementing recycling strategies in a construction site and to achieve an environmentally friendly deconstruction (Schultmann & Rentz 2002, 399). Weil et al. (2006, 197) present a closed-loop recycling model for the use of structural engineering waste in the production of concrete.

3 SUPPLIER COLLABORATION FOR SUSTAINABILITY

In the construction industry, as mentioned before, the proportion of material purchases and subcontracts in the total cost of a construction project is typically around 60-80%. This means that the suppliers play an extremely significant role in a construction company's supply chain.

As it can be seen from chapter 2, cooperation between suppliers is a recurring theme in GSC policies. This chapter looks at different ways to improve sustainability by improving collaboration with suppliers. For many organizations, sustainability has become a part of strategic planning. This means that sustainability needs to be incorporated to the supply chain strategy as well. Achieving this requires an increase in internal and external collaboration all along the supply chain. (Alzoubi et al. 2020, 708.) This chapter will first look at the basics of supplier relationship management (SRM), which defines who are the suppliers that a company should collaborate with on a deeper level. The second part of this chapter looks at environment collaboration, meaning what can be achieved concerning environmental sustainability if a company collaborates with its stakeholders in these issues.

3.1 Supplier relationship management and collaboration

Most companies have implemented SRM (supplier relationship management) principles, such as an understanding of supplier segmentation, a concept of partnership and collaboration and supplier assessment through review meetings and scorecards on performance. When applying these principles companies often miss the point that in order to be effective, the mindset and behaviors will need to change, for both the customer and the supplier. The oversight of this can lead to not getting the wanted outcome from a significant investment on processes and to a view that SRM is mainly a procurement topic rather than a mindset that should be applied to the entire company. (Easton et al. 2014, 8-10.) This way of thinking develops from the fact that procurement is the main interface with suppliers and is the one looking after these relationships (O'Brien 2018, 43). This kind of silo-based approach often leads to counterproductive messages. This procedural SRM means that a company uses the words like "partnership", and hosts review meetings, but suppliers still win work via tenders and are managed through compliance to contract. (Easton et al. 2014, 8-10.)

When accomplished well, a SRM approach provides competitive advantage as well as fuels growth and brand development. It can also improve efficiency, reduce cost, and reduce the risk on supply side. (O'Brien 2018, 41.) O'Brien (2018, 48-49) emphasizes the idea of sourcing value as the base for SRM. Rather than viewing suppliers as just the means to fulfill orders, but as a source of increasing the company's value proposition, a company can meet their customers' ever-growing demands. Easton et al. (2014, 11-12) propose a holistic view on SRM including all interactions between the supplier and the customer, which they call TrueSRM, presented in figure 2 below. From this perspective SRM is a driver for supplier behavior, enforces the relationship between the customer and the supplier and makes it possible for a company to leverage its size by achieving coordination across its functions, hierarchies, and divisions. This fundamental nature of SRM is the same in every industry, even though understandably the specific needs of suppliers vary between industries.

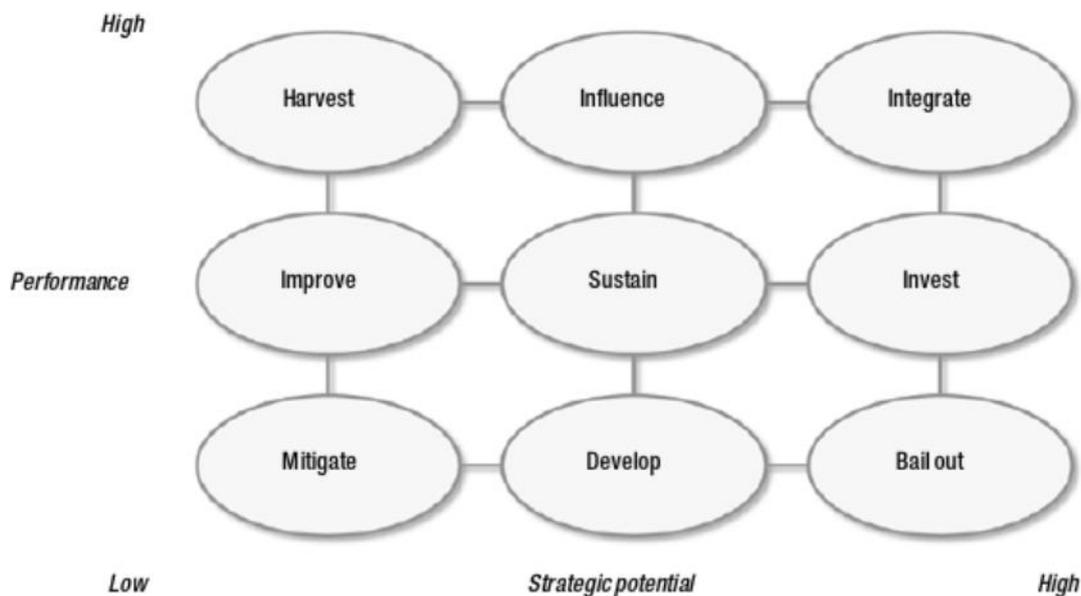


Figure 2 The TrueSRM framework (Easton et al. 2014, 30)

Figure 2 presents the TrueSRM framework. The framework has two axes, the performance axis, and the strategic potential axis. The important supplier-performance variables are time, cost, and quality. Ranking suppliers is a good method when trying to find the best performers and the underperformers, rather than using a grading system, where differences might not be so easily detected. Companies usually evaluate their suppliers'

performance, so this data can be used when forming the ranking. A bell curve would then be formed from the results. Best performers have the most chance of bringing a company's performance to the next level. On the other side of the bell curve, the underperformers need to be evaluated since they might drag the entire company down. (Easton et al. 2014, 30-32.)

Assessing the strategic potential axis is more difficult since there is usually no data to build the assessment on as opposed to the performance axis. Strategic potential means "the relevance the supplier can have in relation to the execution of the company's strategy". Therefore, this kind of a supplier is a key to the company's competitive advantage. It is important to note that a company might have strategic potential even though its performance at the time is not adequate. The strategic potential of a supplier can be evaluated through indicators such as growth, innovation, scope, and collaboration. Growth as an indicator means the possibilities that the supplier can unlock for the company, such as generating sales with new customers through wide geographic reach. Innovation can mean owning technologies and patents, and scope means that the supplier is able to support the company in all of its divisions. Collaboration indicates that the supplier displays the right mindset when working together with the company. (Easton et al. 2014, 32-33.)

The number of potential strategic partners to a company might only be a handful or two. 90% of suppliers have low strategic potential, and of the remaining 10%, about 2% have high strategic potential and 8% have medium strategic potential. Ranking the potential strategic partners should be done by identifying the suppliers with high strategic potential, and then moving down. Evaluation on the performance axis should be done in the opposite direction, moving from worst performers to the best performers. (Easton et al. 2014, 33.)

Figure 3 on the next page presents nine interaction models, which has the same titles as the TrueSRM model. Three in the top right corner are called the critical cluster. These types of suppliers offer the most promise, and these relationships are worth spending time and effort on.

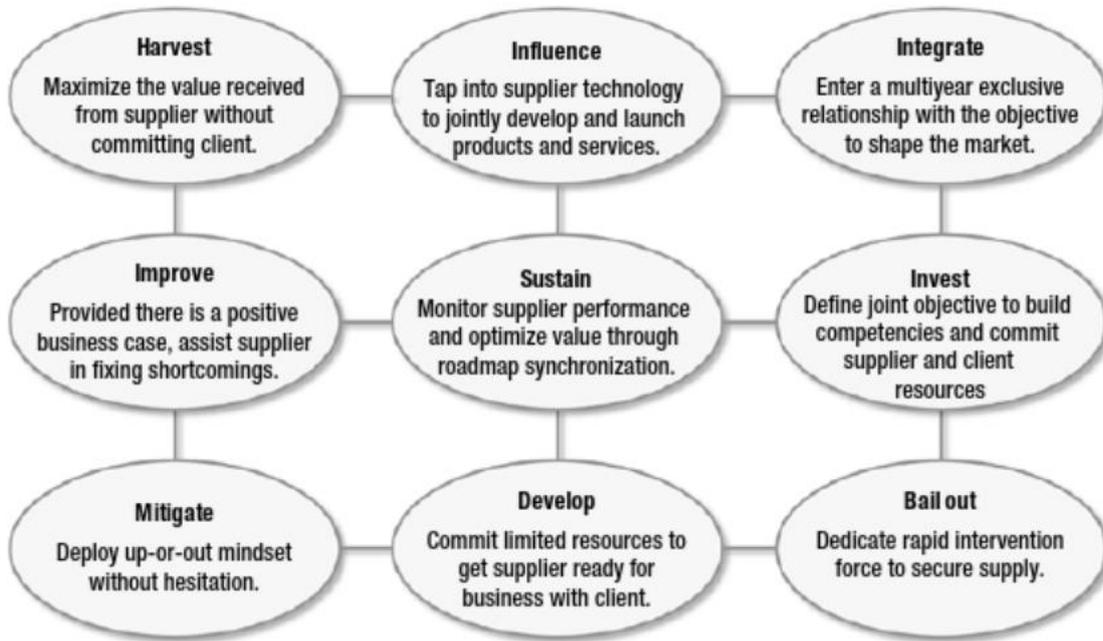


Figure 3 Nine interaction models (Easton et al. 2014, 35)

Integrate means situations where the company and supplier are true partners, and the two companies are integrated. A supplier in this box of the model should have flawless performance and hold the key for competitive advantage. This type of partnership is rare and should be based on a comprehensive relationship built during multiple years. *Influence* is about suppliers who dominate an industry by innovation. With these suppliers it is possible to develop new products. Even though it might not be possible to create an exclusive partnership with these suppliers, it is important to maintain a relationship to avoid the risk of falling behind of competitors. *Invest* signifies suppliers that have great ideas but are in the need of improvement in their performance. When investing effort, money, and resources to these types of suppliers, an *integrate* level partner can be found. (Easton et al. 2014, 35-36.)

The top left and center present ordinary suppliers. There is usually a greater amount of these types of suppliers, and even though they are average, they should not be overlooked. A well-functioning relationship exists with *harvest* suppliers. These suppliers have great performance, and they do not tie up resources. A low level of strategic potential implies however that they are not critical cluster level suppliers. A satisfactory level of performance discussion should be present to avoid negative interaction between the

companies. *Sustain* suppliers are average in performance but they are necessary relationships for the company. These suppliers do not require significant investments or fixes. *Improve* suppliers are numerous and perform a bit more poorly than *sustain* level suppliers. These suppliers are however more easily replaced. Since the relationship with *improve* level suppliers can be unstable, trying to increase their performance level is a good idea. (Easton et al. 2014, 36-37.)

The bottom three performers are called the problematic suppliers. *Mitigate* suppliers can be identified from occurring poor performance in the areas of delivery, quality, and cost. These types of suppliers need to be let go. When a *mitigate* level supplier is a small one, replacing it should be relatively easy, but if the supplier is a bigger one that works on multiple lines of business, replacing it is a harder task that will require time and effort. When a supplier performs weakly but has a ton of potential, a *develop* relationship can be built. This type of supplier needs to be picked carefully, since *develop* relationships need to be nourished for multiple years to bring their performance to a better level. A *bail out* relationship is generally formed when a major supplier commits an atrocious error or when a chronic problem requires fixing immediately. Supplier's performance in a *bail out* case should be first stabilized, and the situation should be regarded as a temporary step towards a better supplier relationship. (Easton et al. 2014, 37-38.)

O'Brien (2018, 54-56, 67) segments suppliers with just one variable, degree of importance. This type of segmentation produces a pyramid figure, where low degree importance suppliers are a vast majority forming the base of the pyramid. As the level of importance rises, the fewer suppliers are left. The suppliers at the bottom of the pyramid do not require special intervention, called the transactional suppliers, and the top of the pyramid are supplier with whom a close collaborative relationship should be formed, called the strategic suppliers. The suppliers in the middle of the pyramid are called important suppliers, which require some level of management. Factors determining supplier importance are for example risk, business importance, spend, innovation ability, sustainability, distribution channels etc.

3.2 Sustainability collaboration

Vachon and Klassen (2008, 309) define environmental collaboration as “encompassing joint environmental planning activities and cooperation in finding solutions to environmental challenges”. According to them this type of collaboration can affect environmental and manufacturing performance positively, when done with major customers and primary

suppliers. Chen et al. (2017) present a literature review of 174 articles concerning supply chain collaboration for sustainability, and the conceptual framework is presented in figure 4 below. The investigated collaborations include internal collaboration, collaboration with suppliers, collaboration with customers, collaboration with competitors and collaboration with other organizations. According to the review most articles investigated collaboration with supplier. Numeral studies have also been made on internal collaboration and collaboration with customer, while collaboration with competitors and other organizations is not a common subject for articles concerning sustainability collaboration. When dividing sustainability into the three areas, economic, environmental and social, the review remarks that most articles cover economic or environmental sustainability, while social sustainability is less covered in these articles.

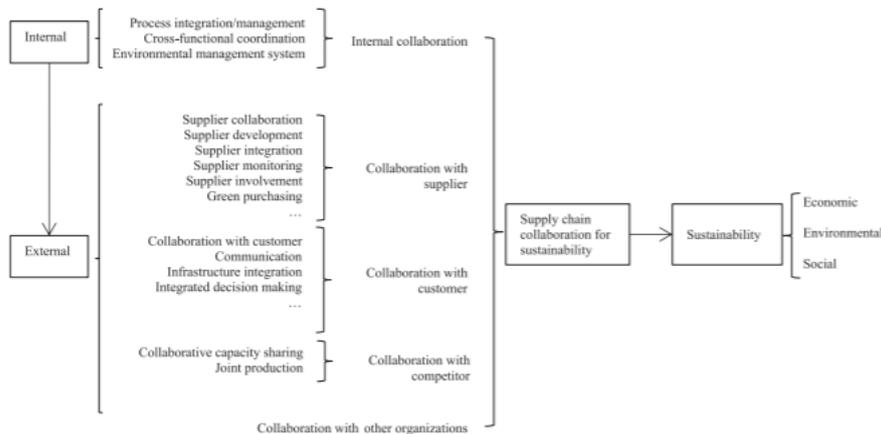


Figure 4 Conceptual framework for supply chain collaboration for sustainability (Chen et al. 2017, 84)

Chen et al. (2017, 82, 84) propose a conceptual framework for supply chain collaboration for sustainability based on their literature review. They recommend firms to evaluate the sustainability performance in economic, environment and social aspects. Next the firms should perform sustainability collaboration in their supply chains by integrating sustainability activities with supplier, customer, competitor, and other organization collaboration. This enriches the firms' resources and improves their capability to achieve better sustainability performance. While they note that collaboration with suppliers and customers is a method that is used more frequently, collaboration with competitors and other organizations should not be overlooked.

Wiengarten and Longoni (2015, 148) assess the impact of supply chain integration (SCI) on sustainability performance. According to Vereecke and Muylle (2006, 1192) companies collaborate in two different forms. The first form of collaboration includes exchange of information, such as information on planning, forecasts, inventory, and delivery. The second form of collaboration is more comprehensive and structural way of collaboration, for example the installation of Kanban systems, co-locating plants or initiating vendor managed inventory (VMI). Wiengarten and Longoni (2015, 148) name the former form of collaboration as coordinative outward-facing integration and found that this type of collaboration positively impacts sustainability performance as well as operational performance. They name the second form of collaboration as collaborative outward-facing integration and found that this method of integration creates better flexibility and even better sustainability performance compared to the first form of collaboration.

3.2.1 Adapting sustainability collaboration and governance

When managing sustainability along the supply chain, sustainability policies need to be extended to the suppliers. Organizations have developed different governance mechanisms to achieve this goal, such as collaboration with suppliers and supplier assessment. In supplier assessment, firms evaluate supplier's performance. This reduces the risk of the supplier acting unethically and/or illegally. Collaboration with suppliers is a key factor in improving environmental performance. Collaboration with suppliers can for example mean providing the suppliers with training. (Gimenez & Sierra 2013, 189, 197.)

Yang and Lien (2018, 11) studied three governance mechanisms for GSC partnership. These governance mechanisms are contract, problem-solving collaboration, and information-sharing. This study suggests that companies should adopt multiple governance mechanisms for GSC to be a viable strategy. The effects of contractual governance combined with a relational adaption may make GSC collaboration more effective. Even though contractual governance is effective, using contracts as a single governance mechanism has limitations.

Cheung and Rowlinson's (2011, 480, 493) study examines the mechanisms to manage relationships along the supply chain and ways for collaboration to be enhanced in SSC's. According to the study the concept of relationship management needs to be implemented to every part of the supply chain in order to establish a sustainable supply chain. SSC also requires an appropriate organization culture and proactive relationship management.

Liu et al. (2018) evaluate supplier development for sustainability (SDS) practises. SDS is an approach to manage supply chain sustainability and also includes supplier selection and evaluation (Yawar & Seuring 2017; Zimmer et al. 2016). The outcomes can be described with two approaches: coverage and performance. Coverage means the workload and resources investment used to implement SDSs, while performance evaluates the suppliers' environmental and social sustainability performance before and after SDS practise implementation. High degree of coverage and performance leads to significant improvement on carbon emission reporting as well as energy saving of supplier facilities. (Liu et al. 2018, 109, 111.)

According to the articles presented in this chapter collaboration leads to better sustainability performance. Companies can use different governance methods and choose the coverage for these methods. A study by Lozano et al. (2021, 8) however remark that collaboration can create challenges, and while excessive collaboration leads to a better sustainability performance, it also leads to a great number of challenges. Based on this they suggest "optimal collaboration", where sustainability benefits are sufficient, but challenges are fewer than in excessive collaboration.

4 ENVIRONMENT COLLABORATION IN CONSTRUCTION

4.1 Positioning the research questions

Srivastava's (2007) figure 1 and Chen et al.'s (2017) figure 4 are used to position the research questions in the current literature in figure 5 below. Srivastava's figure 1 is simplified on the left, with green supply chain management and its literature's three main topics: importance of GSCM, green operations, and green design. On the right Chen et al.'s figure 4 is summarized with supply chain collaboration for sustainability and its 4 main areas: internal collaboration, collaboration with supplier, collaboration with customer and collaboration with competitor.

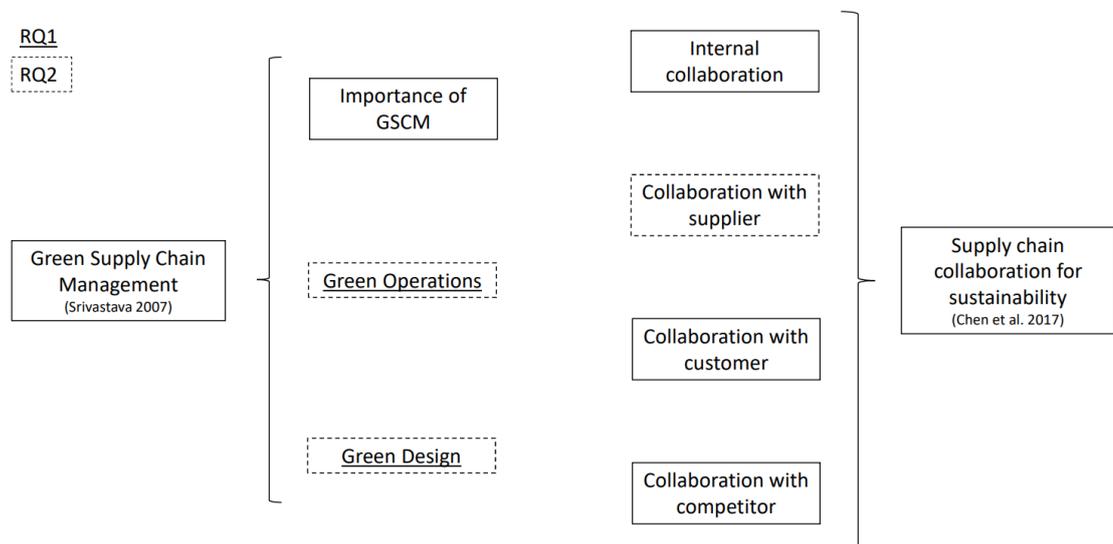


Figure 5 Themes presented in theory in relation to the research questions

Research question 1 (RQ1) focuses on how a company can improve their environmental sustainability with processes provided by the literature of green operations and green design. Research questions 2 (RQ2) looks at these two topics and brings the collaboration view into consideration. Even though collaboration with the supplier is in the core of this study, other collaboration forms surfaced in the interviews and will be touched at as well, mainly collaboration with customer.

4.2 Theoretical framework

Figure 6 combines the key mechanisms presented in chapters 2 and 3 that companies can use when implementing GSCM into their operations. Figure 6 separates the mechanisms from other GSCM literature, in order to be able to provide the case company with specific actions they can do to achieve better environmental sustainability. Figure 1 in chapter 2.1 by Srivastava (2007) divides green operations in GSCM to green manufacturing & re-manufacturing, reverse logistics and network design and waste management. These are presented in figure 6 as *production*, *logistics* and *recycling*. As pointed out in chapter 2.3 by Berry and McCarthy (2011), construction companies are taking responsibility for their environmental impact setting their own standards in their value proposition and trying to win competitive advantage. This can be found on figure 6 as *reason for implementation*, and it is divided to competitive advantage and value. This represents how some companies are implementing green initiatives as their company value, while others are doing so purely for competitive advantage.

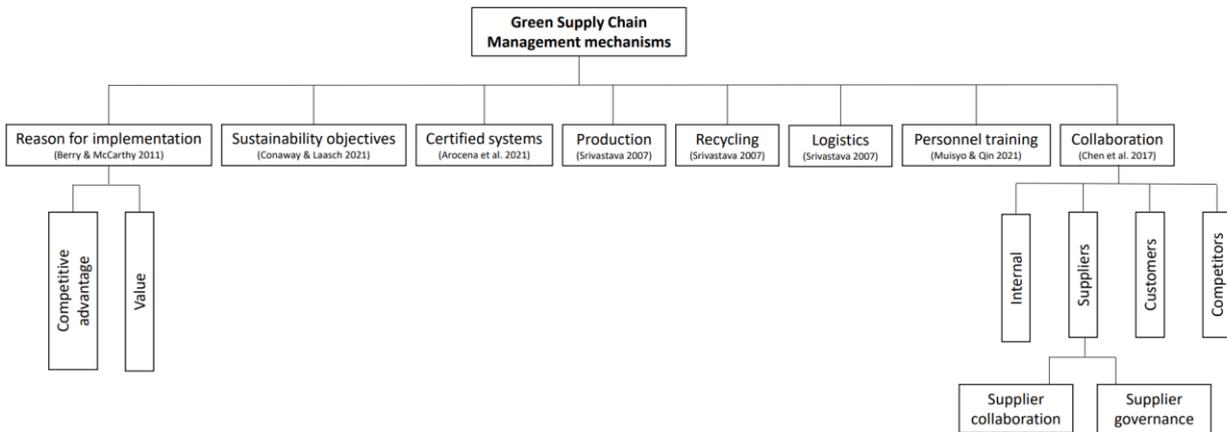


Figure 6 Green Supply Chain Management mechanisms

Conaway and Laasch (2021, 4, 85) identified the importance of vision and mission statements as a critical factor for company’s sustainability performance. Figure 6 presents this as *sustainability objectives*. Research also encourages the use of *certified systems* (Arocena et al. 2021, Treacy et al. 2019, Poltonieri et al. 2019), and this is brought to the GSCM mechanisms after sustainability objectives. *Personnel training* has also been identified as a factor in better environmental performance by Muisyo and Qin (2021).

Sustainability *collaboration*, as presented by Chen et al. (2017) is brought as a mechanism in figure 6 on the right. It is divided into collaboration with different actors: internal, suppliers, customers, and competitors. Supplier collaboration is then divided into supplier collaboration, as presented by Gimenez and Sierra (2013) and supplier governance, as presented by Yang and Lien (2018).

5 METHODS

5.1 Research approach

Walle (2015, 3) remarks that within business, quantitative research has been usually the most preferred choice of method for scientific business research. He also points out that there is a prejudice against alternative research methods, and that these alternatives “are typically lumped together under the category of ‘qualitative methods’”. This ‘lumping together’ can be noticed from Saldaña’s (2011, 3) definition of qualitative research, which goes as followed: “The information or data collected and analyzed is primarily (but not exclusively) nonquantitative in character, consisting of textual materials such as interview transcripts.”

The selection of a method, however, means finding the suitable approach to the particular study in question. Methods have specific benefits, but also limitations and liabilities. The benefits of qualitative research is that it manipulates the environment less than quantitative research, and allows more flexible ways to gather evidence. These features allow a more realistic recording of reality. Qualitative research methods are numerous, thus providing multiple options of significant value to the researcher. (Walle 2015, 8, 12, 15.) Finding answers to the research question calls for the realistic recording of reality, which is why the qualitative method is the appropriate approach for this research. Quantitative research is the method of choice in this particular field of sustainable construction. A literature review conducted by Murano et al. (2020, 5), found that 60% of circular economy construction research was conducted as qualitative research.

This research is a case study. In business research, a ‘case’ is for example an economic actor or unit (Eriksson & Kovalainen 2008, 116). This unit can be a single person, group, event or organization (Saldaña 2011, 8). In this research, the unit, or actor, is the case company Hartela. The goal of a case study is to gain insight from the point of view of this actor (Eriksson & Kovalainen 2008, 2 vai 116). A case can be chosen deliberately for its unique character, strategically for its likeness to other similar units thus providing a representation of its kind, or simply out of convenience (Saldaña 2011,9). Choosing Hartela as the case company is the combination of the two last reasons. In 2019, Hartela was the 9th largest construction company in Finland (Rakennuslehti suurimmat 2019), and therefore represents construction companies in Finland quite well. This combined with

the connections already formed with the case company resulted in its selection as the case company.

5.2 Case Company

Hartela-yhtiöt Oy (in the future Hartela) is a Finnish family company in the construction industry. Hartela employs about 600 people, and its focus is on building apartment buildings and business premises. Hartela-yhtiöt Oy is the parent company, that has three subsidiaries in different regions of Finland: west, south and north. It has six offices, which are in Helsinki, Lahti, Turku, Tampere, Rauma and Oulu. (Hartela.) Hartela is implementing a new strategy that includes sustainable development as one of the main pillars of the strategy. Below are areas they wish to focus on concerning the environmental sustainability (CPO Hartela email 14.9.2020):

- Increasing the level of recycling in construction sites
- Diminishing the carbon emissions of projects
- Calculating the carbon emissions of each project
- Defining and using sustainable procurement criteria
- Using the energy system guidelines
- Diminishing carbon emissions caused by Hartela

The research was conducted in order to produce information to Hartela to support its new environmental sustainability targets. The research also provides Hartela benchmarking as it shows where companies in the construction industry are concerning their environmental sustainability. The aim is that Hartela can start improving their environmental sustainability more efficiently by using supplier collaboration.

5.3 Research design

This research consists of a literature review and empirical data. According to Saldaña (2011, 68) there are different views on whether in qualitative research the researcher should do a literature review before a study. Even though some researchers believe that reviewing literature beforehand anchors the researcher to previously used theories and concepts, he believes that reviewing the literature at the best case leads to making an original contribution to the field, by being familiar with the topic and thus not overlapping with previous research. This is why the literature review was the starting point of this research.

The empirical data of this research was formed by seven interviews, and the basic information of these interviews is presented in table 1 below. A few of the companies preferred to stay anonymous so all the companies are kept anonymous for cohesion. The interviews should be regarded in two different groups. The first group consists of the interview conducted to the case company, and the second group of interviews consists of six interviews, aimed at suppliers of the case company. Eight supplier companies were contacted, of which six were willing to take part in the research. Sampling can be strategic, random, referred and/or serendipitous, and the specific persons that are suitable for interviews and are able to provide concrete answers should be determined (Saldaña 2011, 33). Sampling in this research was strategic, and the interviewed suppliers were chosen because of their importance and/or potential strategic potential to the case company. This way of sampling is usually the case in in-depth interviews (Walle 2015, 19).

Table 1 Basic information about the conducted interviews

Company	Field	Interviewee	Title of interviewee	Length of interview	Interview recorded
Hartela-Yhtiöt Oy	Construction	Sustainability development responsible at Hartela	CEO, Hartela Länsi-Suomi	59:42	Yes
Company A	Window and door manufacturer	Interviewee 1	Environment and quality manager	41:38	Yes
Company B	Kitchen manufacturer	Interviewee 2	Chief business officer	55:00	No
Company C	Hardware wholesales and store	Interviewee 3	Sustainability manager, construction	55:55	Yes
Company D	Door manufacturer	Interviewee 4	Sales manager	55:27	Yes
Company E	Environment maintenance	Interviewee 5	Project manager, environmental services	51:47	Yes
Company F	Concrete manufacturer	Interviewee 6, Interviewee 7	Environment manager, purchasing manager	48:51	Yes

Seven hour-long interviews were conducted for the study. Interviews have strengths and weaknesses as a source of evidence. One strength for interviews is that they are targeted. This means that interviews as a source of evidence are focused directly on the topic of the study. Interviews also provide perceived causal inferences, so they are insightful as evidence. Interviews have weaknesses as well, mostly concerning bias. There can be bias due to unsuccessfully constructed questions or response bias. In addition to these, poor recall can cause inaccuracies and reflexivity can occur. In this case reflexivity means that the interviewee gives what the interviewer wants to hear. (Yin 2003, 86.) The possibility of reflexivity was potential in the interviews, since the CPO of Hartela, was also present in 5 out of six supplier interviews.

Interviews were conducted in a form that had features of the standardized open-ended interview form, as well as in-depth interviews. In standardized open-ended interview form, the questions and their sequence is determined in advance, including the exact wording of the questions. Although this form of interview is inflexible as a method, it does offer a high level of comparability of responses. It also reduces bias when the number of interviewees is high. (Patton 2002.) Even though the sequence of the questions was determined in advance, the sequence and wording of questions was slightly modified in the interview for a better targeting to the interviewee company, and because of limited time.

The themes in the theoretical framework, figure 6, were used to create the frame for the interviews. Interview frame is presented in appendix 1. The interviews started by asking general questions about the company and the interviewee. Next the interview included questions about the company's environmental positioning, company's environmental sustainability goals, and environmental sustainability in the supply chain. Then the companies were asked to tell examples of measures they have taken to improve environmental sustainability by themselves or in collaboration. This also included waste handling, and if there were differences between factories or subsidiaries. The interview frame also included questions about carbon footprint measuring, environmental certificates, personnel training and following the environmental sustainability of their suppliers. The last questions were more reflective questions. These questions were about what challenges the company has before being even more sustainable, and in what kind of areas would the interviewees see possibilities to do environmental collaboration. The interview questions

were commented by the purchasing managers in the consolidated company level, as well as by the thesis supervisor. Due to the fact that at the time of the research the world was affected by Covid-19, the interviews were done via Teams and Zoom platforms.

In some interviews, the answers given by the interviewees also invited other questions, which additionally broke the standardized open-ended interview form. Some tailoring was also made in the question frameworks depending on the field of the interviewed company. These features caused the method to shift towards an in-depth interview form. In in-depth interviews, questions are open-ended, like in the standardized open-ended interview form, but conducted in a more tailored and detailed manner. Sensitive questions are left for the end of the interview to avoid a chilling effect in the interview before most of the data is gathered. The downside of in-depth interviews is its consumption of time, but this can be reduced by limiting the number of interviews. (Walle 2015, 18-19.) In this research, the number of interviews was quite limited, and the time given to each interview was fixed.

The first interview was made to gather background information about the case company, and to be able to position the case company in relation to its suppliers. The interviewee works as the CEO of Hartela Länsi-Suomi, and she is also in charge of environmental development of the company on the consolidated company level. Six supplier companies were chosen by the CPO to be interviewed, and he was present in the interviews as well. Five of the interviews were recorded, one wishing not to be recorded, and the interviewees were mostly in charge of environmental and sustainability matters of their companies.

The number of people involved in the interview ranged from two to four people. The CPO of Hartela attended the interviews to gain knowledge about the state of sustainability in each supplier company, and to exchange ideas. In addition to attending the interviews, he asked the supplier companies to take part in the interview. This resulted in a high response rate, and many supplier companies sending the best person, or in one case people, from their company to answer questions about sustainability.

The interview recordings were written as scripts and these scripts were used to analyze the interviews. All of the seven interviews are first dealt with interview by interview in chapter 6. In chapter 7, the interviews are looked at by the different topics, through the theoretical framework figure 6.

5.4 Research quality

This research presents the chosen methods transparently and presents the findings broadly but concisely. In addition to this, it is necessary to evaluate how the requirements of validity and reliability are met in this study. According to Beuving and de Vries (2014, 42), validity measures whether the research measures what it claims to measure. The research question was formed by the fact that the construction industry's major environmental impacts need to be addressed, and that many companies in the construction industry are aiming to do so, for example the case company. The theory chapters provide background information on the subject, and the theoretical framework offers possible GSCM mechanisms for the case company to use. The interviews were conducted by trying to find answers to the research questions. The theoretical framework is put together with the interviews in chapter 7.1, and the research questions are answered in chapter 7.2, thus measuring what it claims to measure. The research follows a regular research structure and answers research questions by combining current literature with empirical data.

Beuving and de Vries (2014, 42) define reliability as whether repeating the study would yield similar results. Chapter 6 presents the results, and it can be noticed that the different companies had similar methods, even though they produced different products and services in the construction industry. Thus, if repeated, the study would find the same ways that companies must improve environmental sustainability, since they were mostly the same within the six interviewed supplier companies. Based on this the number of selected companies was sufficient to achieve reliability. It must be however noted, that the study was conducted by one individual, meaning that interpretations affected by the personal views of this one individual cannot be excluded.

6 RESULTS

Interview findings are presented with analyses divided to two categories. First all the interviews are presented one by one, by with-in case analyses. After presenting all interviews. In chapter 7 the findings are connected by topics presented in the theoretical framework in chapter 4.

6.1 With-in case analyses

The findings of the interviews are presented in the following sub-chapters, starting with Hartela and ending with company F. The findings are partly presented in the chronological order that the findings appeared in the interview, and partly combined by topic.

6.1.1 Case company

An interview was conducted with the case company to provide an understanding of where the company is concerning sustainability, and what the company is aiming for. The CEO of Hartela west Finland was interviewed since she is in charge of improving sustainability matters in the company. Environmental sustainability will be brought to the company's strategy under the name of sustainable development. Sustainability actions have been taken by the company, but now it aims to do this more systematically. These actions are usually taken on the project level, for example with different energy solutions, such as geothermal heat.

Further courses of conduct are being decided by the executive team and the sustainable development team. The company identifies the direction where the industry is heading with increasing legislation and customer demands regarding sustainability. The encouraging of wood construction by the government has also been noticed, and Hartela has wood apartment buildings starting. The interviewee remarks that the recyclability of wood is now poor and that there are mixed views in the industry about its environmental friendliness. She also points out that with current legislation wood building has a weaker energy efficiency than concrete, and hence a concrete building provides the apartment owner with a smaller heating bill. A building needs to be sustainable and meet the customer's needs at the same time.

Compared to other companies in the industry, Hartela has not made environmental sustainability declarations yet like some other companies have, for example a carbon neutrality goal. But in terms of recycling Hartela is doing well compared to other companies,

according to the interviewee. This approach is how they plan to work in the future as well: first actions, then declarations. This means that the company wishes to first improve their environmental sustainability and communicate their efforts to the public only after implementing sustainability principles. The vision for the company is to be a known sustainable development actor. This has been divided into four areas:

1. Own production
2. Everyday sustainability actions are identified by the personnel
3. Identifying what sustainability means to the clients
4. Identifying long-term sustainability trends

The company's own apartment building construction is highlighted since the company can influence it the most. The aim is to implement sustainability into the entire operation and try to avoid sustainability being an unattached matter for the company.

Under the four areas there are more specific actions. For example, under own production one of the goals is to discover different energy solutions and decide on what energy solutions to use in own production. In terms of sustainability knowledge of the personnel, the sustainability development team was formed out of people who have interest in environmental issues, and the interviewee has noticed that there are many employees in the company who have degrees in the areas of environment and sustainability. The aim is to extend this knowledge for all the employees, so that everybody has the basic knowledge on sustainability. Some clients put more emphasis on energy efficiency while others look at the carbon footprint, and the company's goal is to analyze the clientele and find out which customers emphasize which factor. In regard to the long-term sustainability trends, the sustainable development team includes a lawyer who follows legislation development carefully.

Hartela calculates the carbon footprint of their own apartment buildings to get an idea of how their buildings are doing compared to other companies' buildings. The interviewee remarks that there are different carbon footprint calculation methods, and results differ according to different calculations. These varying results are also the reason why the company has not yet set a goal for the carbon footprint. The goal for 2021 is to analyze the carbon footprint results and find out which factors have the most effect.

A construction project has many stakeholders that affect its sustainability. Hartela practices a site strategy where the environment is an important factor. The company considers which lot to build on, and this includes collaboration with the authorities and landowners. After finding a site, collaboration with building designers and architects begins.

This is the point where the main policies of the building are decided. Carbon footprint calculations of a building starts at this stage, according to its materials etc. The design of the building directs what suppliers can be used, and supplier collaboration begins. To improve environmental sustainability, a construction project in Oulu had close collaboration with a local energy facility to provide a sustainable energy solution and supporting local production at the same time. The company is also building a zero-energy building.

Many office premises are now energy efficiency rated. The foreign LEED and BREAM ratings as well as a Finnish RTS rating are increasing. These certificates take account the entire lifecycle of the building into account, including location, which is a very important factor in these calculations. These projects require evidence of the materials used etc, which requires some additional work, and usually the use of a consultant. This leads to additional costs, but this already a normal procedure in Finnish office buildings. The interviewee views that the biggest change in building sustainability is now seen in the apartment building side of construction industry, and the standard procedure is yet to be determined.

6.1.2 Company A

Company A is a window and door manufacturer. Interviewee 1 is the environment and quality manager at said company. In this company the CPO of Hartela was not present and the interview was recorded. Environment has been taken into consideration at company A in different ways, and the company has many sustainability objectives. In 2020, the company launched a sustainable development taskforce, which is in charge of the bigger picture of the company's sustainability matters. Smaller decisions have been taken in the previous years as well. For example, the electricity in the manufacturing facility is carbon neutral, and with logistics the company has increasingly used a supplier that provides carbon neutral transport services.

In the daily operations of the company sustainability is mostly visible in recycling. The recycling level of the company's product manufacturing is 99%. This includes all the metals, such as aluminum and mixed metals and plastic. Some of the oils are also recyclable, and these are picked up by the hazardous waste collector. In terms of recycling, the interviewee states that some materials are not financially worth recycling, and these are always separately calculated. In the design process of the product, in this case windows and doors, the interviewee states that an important environmental factor is the heat insulation ability of the product. Even though sustainability is most seen in the operations

of the company, the interviewee thinks that the biggest possibility to influence sustainability is in the purchasing and product development part of the business. With this said the interviewee states that all parts of the business are impacted by environmental sustainability.

Interviewee A says that company A is a pioneer when taking environmental issues into consideration. Environmental matters have been needed to take into consideration because of the location of the company's factories. This leads to the idea that taking environmental issues into consideration has been rather a necessity for the company, rather than a value. This is also emphasized by the fact that two of the company's three manufacturing facilities have different regulations due to their location, and in these two facilities the environment issues are addressed better than in the other manufacturing facility. When asked whether environmental sustainability is a value driving the company or a source of competitive advantage, the interviewee starts by saying that the company is looking for a competitive advantage, and that clients create the need for the company to take a stand in environmental issues, as well as the energy efficiency law. The interviewee does also state that there is some ideology in the background.

The actors that company A collaborates with when it comes to environmental matters are clients and authorities. When talking about collaboration with authorities, company A participates in questionnaires made by the authorities about proposed laws concerning sustainability. In the early stage of creating laws, people such as the interviewee are consulted, for example assessing the possible effect that a proposed law might have. Company A is also in close contact with the city's environmental inspector. Collaborating with competitors in an idea that the interviewee denies at once and does not see a future for it either. Since the interview, the interviewee wished to correct that collaboration with competitors is possible, if it is needed (interviewee 1 email 2.6.2021). With clients the collaboration seems to be more one-sided, since the interviewee says that the client's needs are expressed via the sales staff. Another collaboration possibility that the interviewee brings up is the increasing use of carbon neutral transport service, which would lead other transport companies to explore carbon neutral transport possibilities as well. Company A has always actively participated in different sustainability experiments suggested by clients, which are often communicated by the sales staff, and the interviewee sees this as a way to improve environmental sustainability.

Sustainability is managed with a quality and environment system, which challenges the company to think about the environmental matters yearly. Company A calculates its

carbon footprint using an external company for the calculations, and from the year 2018 to 2019 the carbon footprint was decreased by 16%. Carbon footprint is calculated for the company's main product, but not yet on other products. This means that the company cannot provide the client the carbon footprint of the supplied products, but it might be possible in the future, if given the resources. Different certificates also drive the company's actions. Nordic ecolabel is one that comes up most often, and the ISO-14001 certificate, which is an international standard for designing and implementing an environmental management system. The company does not have a Nordic ecolabel product but can manufacture it if needed. This requires some additional paperwork, but not excessively. Projects that are Nordic ecolabel certified are generally public projects, such as schools and campuses.

The staff learns about sustainability through trainings and communication. Errors in recycling are communicated to the interviewee by the recycling service provider, which is then informed to work supervisors. Purchasing handles the control of the suppliers' sustainability by audits, that include sustainability questions. Now theme days about environmental sustainability are aimed at the company internally, but the interviewee admits that these theme days might be extended to the suppliers as well. At this moment intercorporate theme days concern generally work safety, and the interviewee has attended these, organized by clients.

6.1.3 Company B

Company B is a kitchen manufacturer, and the interviewee works at the company as the chief business officer. The CPO of Hartela was present at the interview. The interview was not recorded because of the request of the interviewee, but the interviewee did provide additional information through a slideshow and a corporate social responsibility report. Company B differs from other companies in this study with the fact that their clients are not just construction companies, but 52% of their clientele is private consumers.

Responsible business is the base for company B's every activity, and this is done by recognizing the demands and expectations of important stakeholders, predicting the impacts of the business by evaluating it and its risks, by offering the clients the possibility of making sustainable choices and by collaborating with suppliers to minimize environmental impact and make choices according to sustainable development principles. The company uses suppliers that share their values concerning eco-friendliness and quality

and have built the supplier relationships for decades. Risk management is done in all levels of sustainability, and the measures are following:

- Financial reports from suppliers (financial risk)
- Supplier audits
 - Quality, environment, and safety risks
- The evaluation of risks concerning the ability to produce quality 4 times a year
- Minimizing risks with contracts, for example contractual penalty
- Certificates guiding the business
- Survey of risks in sales, installation, shops, etc.
- Risk management of products, replacing products
- Product development evaluates the risks of new products

As it can be seen from the measures taken with risk management, it is advanced, and its implemented on many different levels with several means of diminishing risk, including a table to evaluate risks.

In 2020 the company launched a program to decrease the emissions from the manufacturing facility, and in long-term to compensate the emissions created by the facility with chosen partners. Company B is also dedicated to offer its clients carbon neutral furniture with minimized and compensated emissions. The company has worked systematically to achieve its goals, with the long-term goal being to be carbon neutral by the year of 2035. The interviewee verifies that the company is a pioneer and that many of the actors in Finland still have a long way to go concerning environmental sustainability, and they wish to bring the industry forward. The carbon emissions of the production are calculated, and in 2021 the carbon emissions will be calculated for the entire operations of the company.

The collaboration with supplier is an on-going process based on discussion. An example of the collaboration with suppliers is their kitchen model that is carbon neutral, for which they needed a sustainable supplier. This required over six months of cooperation with the supplier, and the project overall took over three years. All of the suppliers are audited at least once every five years, and overall approximately 30 supplier audits are done per year. The company has decreased its environmental impact also by minimizing waste by developing a system that produces the kitchen counters with the accuracy of

1mm, and by making the required holes, such as holes for the sink, already at the facility. Issues in the supply chain are found through reclamations, and these reclamations are then brought to the production meetings. For the creation of sustainability ideas, company B has theme days with clients to think about ways to improve environmental sustainability.

For collaboration opportunities, the interviewee comes up with the idea of creating a system to have full transport units when supplying the products to the construction site. In the private consumer side of the business this is already done, but with the construction company side of the business the fact that the companies wish to receive the products one floor at the time leads the trucks transporting partly empty units. The interviewee also suggests that they could be a part of the construction projects already in the designing process, and this way sustainable products could be implemented to the building at an early stage of production. When thinking about the barriers on the way of being even more sustainable, the interviewee states the price. The most challenging part is to ensure that the price of the product remains competitive.

6.1.4 Company C

Company C is a large company with a hardware store that supplies for construction companies. Sustainable development and carbon neutrality are part of the company's strategy. The interviewee is a sustainability manager for the construction side of the business. Compared to other businesses working in the same field, the interviewee finds that Company C is in some areas of sustainability ahead of its competitors, and in some areas behind, but overall sees the company as a sustainable actor. Company's big size and the fact that its functions are widespread also affects its ability to be sustainable, and smaller companies with a narrower sector and a sustainability aspect in their strategy are able to increase their sustainability faster.

The interviewee remarks that the sustainability actions the company takes that are stated in law are not part of the corporate responsibility. Corporate responsibility and sustainability are the actions that the company takes in addition to that. Company C aims to be carbon neutral by 2025 with compensation and by 2030 without compensation. This is done by improving operations and minimizing the carbon footprint of actions, for example by optimizing and recycling. The company might also let go of operations for which decreasing carbon footprint is not possible.

To improve sustainability, the company has acted concerning their packaging. These actions are recyclable package materials and avoiding overpackaging. Company C also

aims to make the client's recycling easier by limiting the use of multilayer packaging, so that the package is ready to be recycled without taking it into parts. Recycling is also part of circular economy, and the company has worked with its suppliers to create closed-loop recycling. Company C also suggests that this could be evolved with Hartela as a cooperation, and the CPO agrees that they could try and think about other ways as well to improve sustainability together. Company's recycling goal is 78% which is higher than what is stated in Finnish law. Barriers in front of higher recycling levels are for example the hardly recyclable construction materials, such as wood. The interviewee however remarks that companies in construction industry are trying to find recycling solutions for the now non-recyclable materials. The company has tried to find substitutes for plastic, but at the same time recognizes that plastic is a good material, as long as it does not end up in nature and is recycled.

Company C helps clients and consumers make more sustainable purchasing decisions by indicating whether a product is sustainably made. The interviewee has worked with their sales department to ensure that the sellers are also able to suggest more sustainable solutions to the customer, and not only when the customer asks for it. Communication about environmental issues is a means for marketing, but also a means for educating consumers. The selection of the company also provides the means to build an energy efficient building. Company C minimizes the creation of waste materials by allowing the customer to order a specific amount of product in the proper length, for example in wood planks. It is vital that the materials used in buildings are healthy and good. The interviewee also recognizes that a long lifecycle of a product is important in sustainability.

Company C works actively with their suppliers to improve sustainability. 200 of company C's biggest suppliers must join the CDP carbon neutrality program, which means creating a program to decrease the company's carbon footprint. This action is driven by the purchasing department. The company has a great number of suppliers and many products come from outside of Finland. The price of the product is still an important factor when it comes to purchasing. With the complexity of the supply chain and with the number of suppliers, the interviewee identifies that some methods of decreasing the carbon footprint of the company might increase the carbon footprint of the supplier. It is also important to notice that things develop continuously, and a method that seemed like a good option a few years ago, might not be that today.

All the suppliers in risk countries are audited by a third party, and social responsibility is a potentially deal-breaking criteria in these audits. Suppliers are also controlled in

sustainability matters with contracts, that include environment as a part of the code of conduct. Different management certificates, such as the ISO-14001 for environmental management system help the management of the suppliers in these matters. New suppliers are always audited, and current ones are audited according to a pre-planned schedule.

Implementation is an important factor is sustainability. Launching a new recycling system takes time, and often is not inculcated in the employees in the first try. The interviewee remarks that in order to implement sustainability principles to the entire organization, it needs to be on the executive team's agenda and a continuous conversation theme in certain areas of the business. The interviewee attends sustainability seminars, and then brings the information and suggestions to the other employees of the company. The personnel of the company learn about sustainability through trainings, such as recycling trainings. Sustainability matters are also a part of training for new employees. Certificates, such as green office certificates also state demands for recycling.

The interviewee brings out the term biodiversity. Biodiversity can be improved by restoring nature. These nature restorations can act as a compensation destination. The CPO points out that even though Hartela has had calculations for the compensation of waste, he sees that it is more vital to first try and correct the company's actions, decreasing the compensation amount and thus decreasing environmental impact. The interviewee agrees and remarks that compensation companies as well make business. The interviewee suggests a three-step model: 1. Fixing and correcting own operations 2. Compensating the rest 3. Moving towards not having to compensate.

In the interview the CPO of Hartela remarks that is construction purchasing the suppliers do not often suggest an environmentally friendly product. The sustainability manager of company C replies that in their case, the suppliers who have sustainability as a strategic emphasis do but agrees that overall suppliers could bring these factors forward. In terms of recycling in the construction site, the CPO recognizes that even in small sites recycling is easy and possible by using good planning and a partner.

CPO and the interviewee both identify the attitudes as a barrier for improving sustainability. "If you only see problems then you only see problems", sums up the CPO. He also brings out the example of a construction supervisor, who did not care about recycling in the beginning. His site was however brought up as an example for good recycling practices, and after that the site manager was extremely proud of the recycling work that they do in the site. This was an example of how attitudes concerning environmental issues can change.

6.1.5 Company D

Company D is a Finnish branch of an international door manufacturing company. The interviewee is a sales manager in the company. Since the company is a material supplier, the sustainability actions mostly concern production. The interviewee remarks that in the last few years the environmental issues have been brought to the side of safety at work. The fact that the company is international is seen at the level of reporting. Regarding sustainability, energy usage, production waste and water usage are reported to the parent company monthly, and their amount objectives are calculated compared to the amount of wood used. The target amounts are also decreased yearly.

The company aims to be ecological where it is possible, and issues that limit these possibilities are for example safety matters concerning the materials. Compared to the other companies in its industry the interviewee views that the company is leading in terms of sustainability matters. The wood material is PEFC and FSC certified, which concern the traceability and sustainability of the material. The company has started to calculate its carbon footprint and the Environmental Product Declaration (EPD) that comes with it, but this is still a work in progress. The interviewee views that the company will be able to provide the carbon footprint of the products in a few years' time.

Sustainability is visible in the company's day-to-day life in the targets and objectives of the company as well as in monthly reports. One of the objectives is that the product is easily recyclable as waste-to-energy (WtE) at the end of its lifecycle. The interviewee has noticed an increase of questions from clients about the recyclability of their doors and remarks the eco-friendliness as a factor that has come to the side of quality and cost. When thinking about waste management and recycling, the goal is to first reduce the amount of waste generated. Waste management is done according to the European Waste Codes (EWC), and the company has signed a voluntary energy efficiency contract. The goal for the company is energy saving of 7,5% by the year 2025. The company uses mostly water-soluble paints and has found other solutions for hazardous additives. Packaging is optimized so that the product is well protected, but at the same time the use of package material, especially the use of plastic as packaging material, is minimized.

The company aims to use sustainable materials in its manufacturing. An example of this is the launch of a new environmentally friendly door, which differs from the other doors on the market with a wooden core instead of a traditional EPS (expanded

polystyrene) core. Sweden and Denmark have strict regulations for the use of EPS, which is still regularly used in Finland. The development process for this product was started by the demand in Scandinavian countries for a new alternative for EPS. The creation of this product has not only helped the company to provide a more sustainable product to the market, but the product also matches well with the tightening fire safety regulations and insulation and decibel requirements. The price of the eco-friendly product is a bit higher than for the traditional EPS core door, but the interviewee recognizes that the product meets customers' increasing demands with both the environmental as well as the quality side. The company has products that are in the Nordic Eco label database. These products are in high demand in Sweden, but not so much yet in Finland. About two years ago the excess amount of work that these environmental certificate buildings required was a lot bigger than nowadays, when the background research for most products and materials is already made and the company has experience with these types of buildings. The interviewee remarks that in Europe and especially in the Nordic countries the environmental sustainability is more advanced compared to the rest of the world.

In Scandinavian countries the use of composite in door thresholds. This material is more eco-friendly than massive wood as a material, but it is not yet popular in Finland. The interviewee also remarks that architects sometimes design hardwood details into buildings, which is not an environmentally friendly approach, since some of these tree species are on the verge of extinction. The company would rather not offer these kinds of trees as materials for clients.

The company mostly makes wooden doors to the Finnish market. Door frame arrives from the company's factory in Estonia. These are then brought to Finland by boat and processed in Finland. Materials come from suppliers, generally by boat, and the finished products are delivered by trucks to the customers. The material suppliers are mostly foreign, but the company has Finnish material suppliers as well. Suppliers are audited regularly, and new suppliers are always audited. The interviewee identifies the logistics as an important factor when thinking about the environment, and the interviewee recognizes that the business requires a large amount of transport.

The company has taken different actions to improve their environmental sustainability in their factories. The factory in Estonia gets its energy from burning the production waste, which makes the factory nearly self-sufficient. One factory in Finland has collaboration with a local district heat company, where company D provides production waste for the district heat company for their energy production, and the heat company provides

the company D's factory with energy, creating a win-win situation. One factory in Finland recycles solvents, if these must be used, since, as mentioned, the company aims to use water-soluble paints. Even though the company's factories are different, they are managed the same, which means that the environmental matters are also handled with the same principles in the different factories. To reduce the environmental impact of the logistics, the company uses a logistics company that aims to be as sustainable as they can in their operations. Company D avoids excess temporary storage which reduces the amount of transport actions needed.

The employees at factories learn about sustainability through waste management trainings and by active communication. The selling organization learns about the environmental aspects of their products so that they can communicate better to the customers as well. Factories also have Environment, Health and Safety (EHS) responsables.

When talking about different possibilities for collaboration between Hartela and the supplier, the interviewee brings out packaging. If the shipments unloaded indoors or under a roof, the packaging around the doors could be lighter, and this would decrease the amount of recyclable material at the construction site. The CPO of Hartela notes that this has been tried with household appliances, and that the experiment was stopped after a few appliances broke, causing extra costs and delays in the site. He does however remark that packaging is under conversation since the construction sites are always looking for ways to decrease the amount of generated waste. The CPO of Hartela remarks the company D's product that has a steel frame and a wooden door. This increases the entire lifecycle of the building since a door can be easily changed when the frame is not.

6.1.6 Company E

Company E does property business and environment management, such as waste management, and the Interviewee is the project manager of environmental services at the company. Environmental sustainability is a focus in the company's strategy, and in addition to improving the company's own environmental sustainability it aims to improve its clients' sustainability as well. The objective of the company is to maximize the recycling of materials and the company also has a goal of cutting their carbon emissions in half by the year 2030. The interviewee views environmental sustainability as a company driving value rather than just a way to achieve competitive advantage. The company views themselves as a pioneer in the industry they are working. The company has set goals for recycling levels of each material and handles a large scale of materials. Circular economy,

climate change, carbon emissions and recycling are closely related to the company's operations.

The company aims to increase their carbon handprint, which is linked to waste and materials that is collected from construction sites. Carbon handprint is created when the need for new material is covered with recycled material, for example plastic. This leads to a decrease in emissions, which is how carbon handprint is created. Diminishing carbon footprint generates carbon handprint. The carbon handprint does not decrease the carbon footprint of Company E, but it decreases the carbon footprint of the company that uses the recycled material that Company E provides. When the waste is sorted correctly already at the construction site, it has more chances in terms of quality to be reused in industry.

Proper recycling in the construction sites requires collaboration between the company E and its client. This starts with providing the site with the right recycling equipment and the training of the construction workers. The quality of the recycling in sites is followed and possible issues are communicated between the two parties. The interviewee remarks that the level of recycling depends on the willingness of the construction company, and the CPO of Hartela replies that not recycling will also increase costs significantly. The interviewee tells that construction waste that is not recycled on site is very hard to recycle after in the recycling facility, and this kind of mixed construction waste can usually only be used to energy production.

Some materials are better suited for recycling than others. If for example a material is very light, it might not be environmentally friendly to transport it to be recycled, since the transporting to a factory far away would create more carbon emissions than the carbon handprint from its recycling. Some plastics are an example of this. Recycled wood is not used as material in Finland, so company E has been forced to try and find a manufacturer that would use recycled wood outside of Finland. The transport distance creates costs compared to the recycled wood being used as energy waste in Finland. There are companies in Finland who are trying to find ways of using recycled wood as a material, but at these projects are not yet in use in the scale that is needed.

Logistics are the biggest source of the company's carbon emissions, and the company optimizes routes and its trucks drive economically. Each truck has a computer that follows the fuel consumption and the way of driving. The company has also declared to acquire vehicles that run with biogas. At the moment the company only has a few biogas vehicles, but each time a truck needs to be renewed, more often a biogas car is bought to replace

it. Company E tested electric and hybrid trucks, but these did not fit with the needs of the company. Factories use eco-friendly electricity.

The company actively tries to find possibilities for use for recycled materials and improve recycling at the sites where the waste is generated. When finding a use for a recycled material, the company works with manufacturers so that they can provide a manufacturer with a recycled material that the manufacturer could use when making new products. This has been done for example with insulation materials, such as glass wool. In the property side of the business, the company provides clients with tools to observe their energy efficiency as well as tips for improving their energy efficiency. Ways to improve energy efficiency in building is for example the change of lights to LED lights and matters concerning ventilation. New sources of energy can also be found for existing buildings, such as solar panels.

Meeting the requirements for recycling for environmental building certificates does not usually require extra work if it is a foreign one, such as LEED. The Nordic Eco label can demand a recycling level of 70%, which might need some extra attention from some companies to achieve and might be harder to achieve in some areas of Finland, for example in the Eastern part of Finland. Some additional reporting might be needed in different certificates. Even though recycling levels and total amounts of generated waste are calculated, Company E does not count these numbers compared to the size of the building under construction, since they often do not have that information. This leads to the fact that the numbers provided by Company E do not express if a site is doing well or not.

This leads the interviewee to suggest the idea of letting Company E know of the purchased amounts from Hartela. The CPO grabs this idea and identifies that this way they could find out how much of the purchased material goes to recycling. This would help calculate if the material buffer is calculated correctly.

The interviewee identifies the calculating, reporting, following and the quality of the calculations of the company's goals as a challenge before being even more sustainable. The company is developing a new management style to address these issues and to become even more systematic when addressing sustainability matters. The demand for recycled materials could be higher. Company E wishes more demand for these recycled materials because at the time they are more in the state of pushing these materials forward. The CPO of Hartela agrees that these facts should also start to be a part of the purchasing decision, for example the amount of recycled material in the product. This interest

towards recycled product would also create more demand for Company E's recycled materials.

6.1.7 Company F

Company F is a concrete supplier in the construction industry. In this interview two interviewees were present and the CPO of Hartela. Interviewee 6 is the environment manager and interviewee 7 is the purchasing manager of the company. Environmental management is very systematic in the company. Company F has environmental goals and objectives concerning climate change, decreasing carbon footprint, and diminishing other harmful environmental impacts. These objectives are about water consumption, energy efficiency and waste management.

The executive management is extremely committed to environmental matters. The environmental steering group consists of the CBOs of the executive management team, CFO, and the environmental team, which meets quarterly. The company has clear systems and programs for environmental management, for example an environmental observation system, that encourages to make observations about the environment. The company has a lot of controls and audits as well for sustainability management. Especially the previous executive management team was a pioneer in environmental issues, and they pushed environmental matters strongly forward. Company F has a program to promote biodiversity, and interviewee 6 views the company as a pioneer in this area of sustainability, but also remarks that even though they had an early start with their program, other companies have since developed similar programs. Interviewee 7, the purchasing manager, also remarks that the increasingly tightening environmental law has made other companies improve their sustainability.

Company F works actively to develop new products that would help decrease carbon emissions. One example is a green version of their main product which has a smaller carbon footprint than in their regular products. Its demand has increased during the last few years, but Interviewee 6 does wish that it would have more demand. The company also has another product made of recycled materials. The recycling process is precise. Company F recycles concrete, wood and metal, as well as paper and cardboard. Hazardous waste is collected. Concrete waste is recycled within the company and made into a new product. Concrete waste is also collected from other companies for the manufacturing of this product. Manufacturing waste is used as well immediately for new product.

Company F's supply chain is complex, and it has hundreds of raw material suppliers, material suppliers and subcontractors. Logistics is handled by subcontractors and storage is also an important part of their supply chain. The sustainability matters are targeted along the entire supply chain. Suppliers are audited, and the audits include environmental matters. Sustainability matters are also under discussion when drawing contracts. In addition to this, company F's suppliers present their new products and services and improve sustainability in this way. Carbon footprint is calculated for products separately, and these include life cycle calculations. Company F can calculate carbon footprints for different sectors, for example for a specific manufacturing facility.

Concerning energy efficiency, interviewee 6 feels that ISO-50001 standard gives a good framework for energy management. This standard includes energy analyses and inspections. An energy work group was established to oversee these matters and finds areas for development. These areas can be found either by the analyses and inspections, or by employees' environmental observations. When an area for development is found, a plan and a schedule is made and responsibility for the project is assigned. Then the influence of the project is measured.

The process described by Interviewee 6 is presented in the figure 7 below. This process is systematic. An example that the interviewee 6 gives about a project is switching a manufacturing facility's heating from fuel oil to district heating done with wood briquettes. Lighting has also been widely switched to energy saving LED lamps, heating is balanced in large spaces with propels, and doors and windows are better insulated.

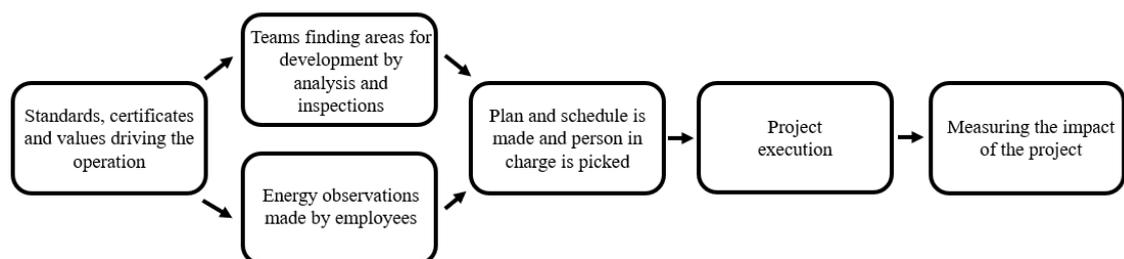


Figure 7 Company F's process for new sustainability actions

Collaboration with authorities is quite active. Company F's employees are a part of workgroups that prepare legislation for their industry, and it is very rare that a new legislation would be regulated without their knowing. Sometimes authorities are also in the way of sustainable activities. For example, a permit is needed for the use of production

waste in new production, and at times these are hard to acquire since authorities see the use of waste in new production as a threat to quality. There are also differences between authorities in different areas in interpretations of manufacturing waste. The biodiversity program also includes a lot of stakeholder collaboration. The participants of the interview discuss the encouraging that the authorities are giving to wood buildings, which creates astonishment. Interviewee 6 remarks that even though wood has less carbon emissions as a material, the use of concrete makes a building's energy efficiency better.

Employees have a mandatory environment training, which includes facts about oil absorption etc. This training needs to be renewed every five years. In addition to this, employees learn about environmental matters through monthly info sessions and monthly info packages, which needs to be signed. The environmental team also creates training packages about sustainability. Environment instructions must be learned by all the employees. Company F's Intranet, info TV screens at branches, and its client magazine also work as communication channels for sustainability issues.

Interviewee 6 identifies the large scale of the company compared to the 4-person environment team as a barrier towards being more sustainable. Another barrier is the criteria that new products must meet. In terms of collaboration with clients, interviewee 6 identifies clear contracts and good information flow as important factors when improving sustainability. Interviewee 7 also remarks that if company F as a supplier for Hartela could be a part of the design process, environmentally friendly products could be included in a new building more easily. The CPO of Hartela also recognizes that collaboration at an early stage is required when implementing new products to a building and wishes for the supplier to be active in suggesting sustainable options. He also hopes that the buyer of the building would put more pressure for selecting sustainable products.

7 DISCUSSION

7.1 Interviews and the theoretical framework

As it can be seen from the interview analysis in the previous chapter, companies that have sustainability as a part of their business have similar ways to take the environment into consideration and to improve environmental sustainability. Table 2 presented below compiles the methods these companies use in their business. The points in table 2 are the same as in figure 6 in chapter 4, except that production is divided to eco-friendly production solutions and product development, and *other projects* has been added to the end. Some methods might be used by the company even though there is not a cross presented in the table, but it merely states that the method did not come up in the interview.

Table 2 Interviews from the view of the theoretical framework

	A	B	C	D	E	F
Sustainability objectives	X	X	X	X	X	X
Seeking competitive advantage	X			X		
Sustainability as a value		X			X	
Certified systems	X	X	X	X	X	X
Supplier governance	X	X	X	X		X
Eco-friendly production solutions	X	X		X		X
Product development	X	X	X	X	X	X
Personnel training	X	X	X	X		X
Recycling	X	X	X	X	X	X
Eco-friendly logistics	X	X		X	X	
Collaboration with stakeholders	X	X	X	X	X	X
Other projects			X		X	X

Objectives and certified systems are the base for sustainability and work as guidelines that take the business forward. The background for sustainability is often either a

competitive advantage or a company driving value. The companies are actively auditing their suppliers or have other restrictions and goals that their supplier base must achieve. The companies that have production facilities are increasingly finding ways to limit the environmental impact of their production, with for example eco-friendly lighting or by choosing an energy source with a smaller environmental impact. Eco-friendly products are being developed that have a smaller carbon footprint.

The staff is trained about sustainability and issues concerning it are communicated to all the levels of the companies. Recycling is important, and the emphasis is often in diminishing the creation of waste. Logistics has been identified as a big source of pollution, and this has been taken into account by using better transportation methods, such as trucks that use biogas, and by optimizing transports and decreasing the number of needed transports by loading trucks full and limiting the use of temporary storage. All of the companies also collaborate actively with its stakeholders about sustainability matters, whether it's with suppliers, authorities or customers. Half of the companies also had projects that were not directly linked in their business, such as projects to increase biodiversity.

7.2 Answering the research questions

The objective of this research was to find ways a construction company can improve its environmental sustainability with the focus on supplier collaboration. This study combines the theoretical frameworks of green supply chain management in construction and sustainability collaboration. The first research question focuses on GSCM mechanisms, the question being:

RQ1: What mechanisms can a construction company use to improve its environmental sustainability?

This study identifies the following mechanisms to improve environmental sustainability in the construction industry:

- Setting sustainability objectives for the company
- Applying sustainability as a company value or to seek competitive advantage
- Implementing certified systems
- Practicing supplier supervision

- Finding eco-friendly production solutions
- Investing in product development
- Implementing personnel training
- Practicing recycling
- Finding eco-friendly logistic solutions
- Collaborating with stakeholders, such as clients and authorities
- Implementing projects that improve environmental sustainability but that are not directly linked to company's processes

GSCM mechanisms were first found by reviewing current GSCM research. This theoretical framework, figure 6, was adapted to fit the mechanisms presented in the interviews in table 2. The mechanisms were then made into the list above. Compared to literature, the points on the list were already presented in the theoretical framework. The interviews brought the need to separate production into finding eco-friendly production solutions and investing in product development. The interviews also brought the last point, other projects, as a new addition to current literature.

The second research question looks at what collaboration can give to environmental sustainability. Research question 2 is:

RQ2: What are the ways that a construction company can improve its environmental sustainability by collaborating with its suppliers?

When looking at the mechanisms that this study found to improve environmental sustainability, most of these methods require collaboration with stakeholders, or the development is faster by using collaboration. Method, such as practicing supplier supervision, is directly linked to supplier collaboration. Other methods, such as finding eco-friendly production solutions, doing product development, recycling, and finding eco-friendly logistic solutions can be achieved easier by collaborating with suppliers. An example of this is company E communicating with manufacturers in order to find a use for their recycled product, or company D working together with a local heat company by providing them with waste to burn and getting that energy back into their manufacturing facility. These are examples of win-win situations found by working together with actors in the supply chain. The actions of the companies show that the companies recognize the added value

of sustainability collaboration, as presented in literature, but compared to all the added benefits literature presents, there could be even more collaboration.

7.3 Theoretical contributions

Kubba (2017, 55) remarks that due to realizing that sustainability and green building are important selling points in the construction industry, an increasing number of builders are engaging in green building practices. This can be seen in the presence of GSCM practices in the interviewed companies, and these are discussed in this chapter. Srivastava (2007, 68) states that GSCM can reduce the environmental impact of an industrial activity without sacrificing cost, quality, performance, reliability or the efficiency of energy utilization. The win-win situations presented by companies D and E support this and demonstrate that environmentally friendly solutions can be cost-effective. Simultaneously in the interview with company F it was identified that the use of waste material in production can be seen as a threat to quality, which contradicts with Srivastava's statement.

GSCM operations presented by Srivastava (2007, 59-62) arose quite fully in the interviews, such as reducing the use of virgin materials, recycling, and reducing the formation of waste. Companies in this research also focused on the energy efficiency of their products, contributing to green design. The principal presented by Achillas et al. (2019, 2-3) that sustainability must be extended from the company level to the supply chain level, was well recognized in all of the interviewed companies. Interviewed companies had implemented certified management systems, such as the ISO14001 system, which is encouraged in research (Arocena et al 2021, Treacy et al 2019, Poltonieri et al 2019).

Weinhofer and Hoffman (2010, 80, 85) presented the ways to implement carbon management strategies. Carbon reduction was strongly present in the interviewed companies' operations, such as company E's use of biogas trucks and company F's development of manufacturing facilities to be more energy saving. Of the researched companies, companies B and C use compensation in addition to carbon reduction. Company C is using compensation to be carbon neutral quicker, and then continuing the development of the business in order to not having to compensate. Company B views compensation as the last correction to achieve full carbon neutrality. Thus, Weinhofer and Hoffman's (2010, 80, 85) remark about companies using many carbon management strategies simultaneously is supported by this research. Personnel training was also an important part of making the companies' businesses more sustainable, as proposed by Muisyo and Qin (2021, 9).

Kibert (2016) expresses subcontractor training as a risk for implementing new green processes to the supply chain. This is identified by company E, who actively train their clients in recycling processes. Achillas et al. (2019, 40) suggest adding social and environmental criteria to procurement. This is best demonstrated in company C's efforts to make their vast supplier base greener by requiring them to be a part of the CDP. Achillas et al.'s (2019, 40-41) presentation of strategic sourcing, including value creation, risk management, overall resilience and responsiveness is company B's supplier risk management, which is a structured risk management system, with supplier audits and minimizing risk through contracts.

Kibert (2016, 479-480) suggested that procurement should be accurate so that no excess material is left on-site. A suggested way of handling this would be for the manufacturer to buy back unused material that could still be used. Hartela's and company E's idea about letting the waste handler, company E, know about the bought amounts by Hartela and this way calculating the percentage which goes to waste offers a more proactive solution to this problem by limiting the creation of excess material.

Many of the interviewed companies had other projects that were not linked directly to their processes to improve environmental sustainability. This mechanism did not come up when reviewing literature. The interviewed companies that have these were very proud of these projects, and it would be safe to assume that these extra projects are good for the company's image as well. Engin et al. (2019, 5.) suggested that implementing GSC policies is indeed very good for the company's image.

Vachon and Klassen's (2008, 309) research suggestion about collaborating with major customers and primary suppliers to create positive impacts on environmental performance is clearly present in the ambitions of the case company. Vereecke and Muylle (2006, 1192) present two different forms how companies collaborate, a basic form and a more comprehensive form. The ambition for the latter form of collaboration was present in this research. Deeper collaboration, such as company D's collaboration with the local heat company, and the suggestion from company F to incorporate the supplier to the design process of the case company are examples of this kind of deeper collaboration.

Yang and Lien (2018, 11) study present three governance mechanisms for GSC partnership, which are contract, problem-solving collaboration, and information-sharing. Company B has implemented these mechanisms in their supplier governance, by mitigating risk with contracts and by searching and working close with a supplier in order to produce a carbon neutral product. Company E's and case company's shared idea to start

sharing information about the ordered material amounts in order to calculate the percentage of materials going to waste works as a great example on how information sharing can improve environmental sustainability.

Literature recognizes that collaboration with suppliers is a key factor in improving environmental performance. (Gimenez & Sierra 2013, 197.) The interviewed companies had a lot of collaboration with different stakeholders, such as authorities and clients. From the point of view of these interviews it should be noted that in terms of supplier collaboration, the emphasis was still on the supplier governance side rather than supplier collaboration side. Additionally, Chen et al. (2017) divided sustainability collaboration to be internal, with suppliers, with customers, or with competitors. Based on the strict answer provided by company A, the construction industry in Finland is not yet ready to collaborate with competitors. Companies A and F actively collaborate with authorities, which brings another actor to collaborate with into Chen et al.'s framework.

7.4 Recommendations for the case company

Junnonen and Kankainen (2012, 5) observe that purchasing in the construction industry has evolved from the simple operation of buying materials and services to cooperation with subcontractors and material suppliers. This development has been in the core of this research and was strongly present in the interviews. The point made by Easton et al. (2014, 8-10) that SRM is mistakenly seen as a procurement topic should be evaluated within the case company and apply SRM to the company level to achieve the wanted outcomes in sustainability efforts. It would also be beneficial to the case company to review the supplier base in Easton et al.'s (2014) framework keeping in mind that it is important to pick the right suppliers to start collaborating with, and also which badly operating suppliers should be mitigated. The case company has a clear aim to collaborate with suppliers and customers. Chen et al. (2017) remark that this is often the case and that collaboration with competitors and other organizations are often overlooked when it should not be. Assessing the possibilities of collaborating with competitors and other organizations could be a method for the case company to achieve their environmental goals even faster.

Kubba (2012, 67-68) presented criteria to evaluate how green a building is. While the case company can work closely with its supplier, company E, to improve waste management, and use sustainable products that companies B, D and F make, about half of Kubba's (2012) criteria need to be considered in the designing of the building. These

factors are sustainable site planning and a building design that minimizes environmental impact. To reach all of the points made by Kubba (2012), the case company should first evaluate that the design of the building is sustainable, and then use the appropriate suppliers that can provide the company with sustainable materials and processes. Working with the suppliers already in the design process to incorporate the sustainable products in the buildings should be considered, as company F suggested to the case company.

The interviewed companies are very familiar with the rise of green building ratings systems, such as the ones presented by Kubba (2017, 27), and implementing these rating systems more broadly would be beneficial to the case company, so that the evaluation of environment impact is easier. The case company should also review the building of zero energy buildings, since it is a relatively new concept in the construction industry, and a widespread market penetration of ZEB's is predicted by Andersen (2017, 69).

Having the case company as well as the interviewed companies present in the interviews showed how companies can easily exchange ideas and find solutions with the will to collaborate simply by meeting and opening the discussion. Even though the major contributions of this study was finding mechanisms that pioneers in sustainability in the construction industry of Finland use, the number of ideas exchanged show that these types of meetings held in the future can be an excellent method to improve environmental sustainability more efficiently than by reviewing these matters within the company.

7.5 Limitations and future research suggestions

This research offers contributions to the GSCM and sustainability collaboration literature by presenting that the policies in GSCM literature are strongly present in the practices of companies that aim to improve their environmental sustainability. This study also shows that sustainability objectives can be achieved more effectively by collaborating with suppliers and other stakeholders actively. Noticing how the same methods were repeated in different companies shows that the number of companies interviewed was sufficient to benchmark the Finnish construction industry. However, as the interviewee in company D remarked, Nordic countries are ahead of the rest of the world in the sustainability matters, which means that this study is limited to this region of the world.

This research focused on improving the environmental sustainability in the construction industry with supplier collaboration. Chen et al.'s (2017) literature review on sustainability collaboration presents that economic and environmental sustainability are more covered in this literature rather than social sustainability. Based on this there is room

for researching the subject presented in this thesis, but instead of choosing the environmental aspect, looking at the social sustainability aspect. The case company and company F have remarked the wood building versus concrete building debate in Finland. Current research (Gustafsson et al 2020, Rebane & Reihan 2016) supports the use of wood as a construction material. The debate on the construction industry, as well as the limited amount of research shows that there is more room to research this subject.

8 CONCLUSION

The aim of this research was to find methods a construction company can improve its environmental sustainability with the focus on supplier collaboration. It was performed as a qualitative case study by interviewing the case company's six different suppliers that are pioneers in the construction industry. The study also included an interview with the case company in order to provide an understanding of the company's objectives and to see how the company is doing in terms of environmental sustainability.

The second and third chapter offered a literature review about the two theoretical frameworks used in this study. Chapter 2 examined the GSCM policies, providing information and possible ways to improve environmental sustainability in the construction industry. Chapter 3 looked at the concept of sustainability collaboration, and how implementing sustainability to the entire supply chain is crucial and how collaborating with stakeholders can help a company to achieve its environmental targets more effectively. Chapter 4 brought these theories together and found mechanisms that the companies can use to improve their environmental sustainability.

Through the seven conducted interviews specific methods, mostly matching with the theoretical framework, were found to improve environmental sustainability. The methods presented in the interviews aligned with literature, and as suggested by the sustainability collaboration literature it was noted that collaboration is indeed a key element in order to improve environmental sustainability, especially in the construction industry where procurement is a significant part of the business. The interviewed companies are all part of the construction industry but produced different products and services. The same methods found in all of the different companies indicate that the results can be extended to other construction companies in Finland, and not only to the case company.

This study offers the actors in the construction industry ways to start diminishing the major environmental impact the construction industry has on the world. The interviews show that many companies have already started to tackle this issue, but a lot more can still be done. Based on this study it can be expected that the environmental sustainability in the construction industry will keep improving, and in the near future the environmental sustainability will not only belong to the pioneers but will have to be incorporated to all companies working in the construction industry.

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APPENDICES

Appendix 1. Interview frame

Pro gradu/Johanna Malin
Interview frame
Environmental sustainability interview

Interview frame

1. Company name, interviewee background
 - a. Name of the company:
 - b. Can the name of the company be used in the thesis or should it stay anonymous:
 - c. Name and title of interviewee:
 - d. Can the name and title of the interviewee be used in the thesis or only title:
 - e. Can the interview be recorded:
 - f. Does the interviewee want to read the interview text:
 - g. Can quotes be used:
2. What is your company's situation concerning environmental sustainability?
 - a. What is the role of the environmental sustainability in your company?
 - b. How do you see environmental sustainability in your company's actions?
 - c. Where are you compared to other companies in the industry?
3. What are your short and long-term goals concerning environmental sustainability?
 - a. What kind of collaboration do you require from different stakeholders (own suppliers / client) in order to achieve your goals?
4. Supply chain and how sustainability can be seen in it
 - a. Define roughly your supply chain / network where you work in
 - b. In which part of the supply chain are the best possibilities to improve environmental sustainability?
5. Tell examples of measures your company has taken in order to improve environmental sustainability alone or by collaborating.
 - a. Measures concerning energy efficiency (design) (28%)
 - i. Examples of collaboration
 - b. Measures concerning processes (operations) (11%)
 - i. How do you deal with waste that is created in production?
 - ii. Are there differences between factories/subsidiaries in environmental sustainability?
 - iii. Examples of collaboration
6. Is the carbon footprint measured in your company? How?
 - a. If not, would it be possible to measure?

7. Have you been a part of a building site / building with an environmental certificate? What was the experience like?
8. How does your personnel learn from environmental sustainability?
 - a. Trainings, communication?
9. How do you follow the environmental sustainability of your suppliers?
 - a. Do you train your suppliers in environmental sustainability?
 - b. Do you do collaboration in environmental sustainability?
10. What challenges does your company have before being even more sustainable?
11. What can Hartela do in order to make it easier for you to achieve your environmental sustainability goals?
12. In what areas do you see that is possible to do collaboration in the area of environmental sustainability? / In what areas do you see that environmental collaboration will be done in the future?