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Greening of Global Value Chains: from a top-down and bottom-up perspective

A multiple-case study of how GVC actors are addressing greening of GVCs through reducing CO2 emissions from road transports

Graduate School
International Business and Trade
Master's Thesis
Spring 2021

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Abstract

Previous literature within the GVC research field have mainly focused on economic values, however, recently environmental aspects have increasingly started to be considered. Nevertheless, although road transport is a major cause of CO2 emissions, it has been overlooked in the context of greening GVCs. Therefore, the study aims to enrich this rather under-investigated field by examining how greening of GVCs is addressed by reducing CO2 emissions from road transports with an emphasis on fossil-free fuels. This is done through a qualitative multiple-case study, taking a dynamic approach by including four lead firms (top-down perspective) and five suppliers (bottom-up perspective). The results show that the lead firms mainly adopt captive governance in relation to road carriers. The requirements set by lead firms can lead to an external drive for suppliers to environmentally upgrade, however, it can also weaken the motivation and inhibit the innovation process of suppliers to develop new fuel solutions. Furthermore, this study found that lead firm characteristics, such as if they operate B2B or B2C, influence the sustainability governance. The prerequisites for suppliers to environmentally upgrade are not only affected by the adopted governance structure by the lead firm, but also the suppliers' characteristics as strategic intent, capabilities and competencies. In addition to providing a more holistic view to analyze greening of GVCs by taking both a top-down and bottom-up approach, this study also goes one step further in understanding and grasping the importance of the interconnectedness between lead firms and suppliers through inter-firm collaborations.

Key words: Global Value Chains, Greening, Sustainability governance, Environmental upgrading, Road transport, CO2 emission, Fossil-free fuels

Acknowledgements

We would like to sincerely thank all participating companies and respondents for taking their valuable time to contribute with their professional insights as well as necessary material to our study. This study would not have been possible without all of you. Further, we would like to give a special thank you to Morgan Larsson at Econ for always having our best interest in mind and providing us with his expertise and valuable insights of the industry.

Lastly, we would like to give a large thank you to our supervisor Johan Jakobsson for your genuine dedication, for always supporting and leading us in the right direction. Your feedback and expertise have been invaluable during the process.

THANK YOU!

Gothenburg, 31st of May 2021

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List of abbreviations

B2B - Business-To-Business

B2C - Business-To-Customer

CO2 - Carbon Dioxide

CSR - Corporate Social Responsibility

GCC - Global Commodity Chain

GPN - Global Production Network

GVC - Global Value Chain

HVO - Hydrogenated Vegetable Oil (Biodiesel)

MNE - Multinational Enterprise

VC - Value Chain

1. Introduction

The introduction chapter firstly presents a general background to provide context of the study, followed by a problem discussion highlighting identified research gaps based on previous literature within the GVC research field in regard to greening of road transports. This leads up to the purpose and research questions of the study. Lastly, the delimitations of the study are discussed.

1.1 Background

The world economy and business environment have seen a drastic change in the last few decades. The transformation is due to many factors, including the liberalization process of international trade, together with digitalization and increased developments of information and communication technologies which have underpinned the globalization process of organizations and industries (Dicken, 2015). In turn, Multinational Enterprises (MNEs) have taken advantage of the possible economic gains of increased globalization in terms of strategic outsourcing to low-cost countries to focus on core competencies in-house, resulting in complex geographically dispersed networks of its functions. This phenomenon has introduced theoretical concepts as Global Value Chains (GVCs) and Global Production Networks (GPNs) (Kano et al., 2020). Putting these terms in relation to each other, GVC is often seen as a more comprehensive concept, including the fragmentation and the geographical dispersion of value creation both in support and primary activities, therefore covering not only traditional manufacturing MNEs (Kano et al., 2020), in contrast to GPNs.

In the literature, GVCs are referred to as "*(...) the nexus of interconnected functions and operations through which goods and services are produced, distributed, and consumed on a global basis*" (Kano et al., 2020, p.579). In other words, the GVC framework is concentrated on value chains (VCs) which are expanding globally, and how value can be created and acquired within these (Gereffi & Joonkoo, 2012). Gereffi (2011) explains how one can analyze GVCs from two opposing perspectives, namely, top-down and bottom-up. The top-down perspective focuses on "governance" in the GVC and the role of lead firms (Gereffi, 1994), which can have the role as both producers or buyers in the chain who coordinate and control the activities of suppliers and other associated actors in the VC (Gereffi, 2011). This can also be applied to the governing of environmental issues in the GVC which is referred to as sustainability governance

(Bush et al., 2015). It is important to note that governance does not only refer to direct ownership in this context, but rather power relationships between lead firms and suppliers.

On the other hand, the bottom-up perspective focuses on "upgrading", which traditionally has been referred to as economic upgrading that involves strategies for suppliers to preserve or improve their position within the economy. However, authors have recently started to also consider social and environmental dimensions of upgrading (De Marchi et al., 2013a), as stakeholders are putting high pressure on businesses to increase their awareness of Corporate Social Responsibility (CSR) and creating environmental management and greening strategies. Sustainability reports as a complement to traditional financial and annual reports, and environmental policies in accordance with the UN Agenda 2030 are incorporated into the strategies and businesses of most MNEs today, to meet the requirements of stakeholders and stay competitive. This pressure involves greening of all activities connected to a company's products and not only activities that are carried out in-house (De Marchi et al, 2013a), where greening is a comprehensive term including several processes to reduce the overall environmental impact of a business (Schaefer & Harvey, 1998).

One aspect of a company's greening strategies is to manage future fatal climate changes by limiting the emissions of greenhouse gas, where CO2 emissions make up for the vast majority, which has already caused impacts such as increased temperatures in the atmosphere and in the ocean. According to the European Commission (2020), transport accounts for nearly a quarter of the total amount of greenhouse gas emissions in Europe, while also being the largest contributor to air pollution in cities. Furthermore, the by far largest share of greenhouse gas emissions comes from road transports (72.8%) (European Commission, 2020). Transports are an essential part of GVCs both when moving raw materials for production or processing early in the chain, but also in the later parts where goods are transported to consumers and the transport systems stretch both regionally and globally (Rodrigue, 2020). Many MNEs have realized that they need to take action and have formulated ambitious goals to lower CO2 emissions for transports and become entirely fossil-free. For example, the global giant Amazon has expressed a vision to make all Amazon shipments net zero carbon, starting with a goal of 50% net zero carbon shipments in 2030 (Amazon Sustainability, 2021). Additionally, Volvo Group has set ambitions to produce 100% fossil-free fuel vehicles by 2040 where electromobility plays a large role (Volvo Group, 2020). In order to achieve these goals, firms must explore new ways to do business. However, as stated by De Marchi et al. (2013b), to

understand the greening process of industries, one cannot focus on merely a single firm. Rather, due to the effects of globalization of firms, greening should be analyzed from a GVC perspective to support the understanding of the greening process beyond the focal firm (De Marchi et al., 2013b). Thus, greening of road transportation should be considered from a GVC perspective.

1.2 Problem discussion

The GVC framework offers tools to analyze today's globalized and geographically fragmented business environment, and there also exists a solid amount of previous research on GVCs from different perspectives (Kano et al., 2020) however, economic values have been predominant in this field (Bush et al., 2015). Alongside with the emergence of the GVC literature, the awareness of the negative environmental impacts from GVC activities has risen, giving birth to a new area of research under the label of environmental sustainability. The sustainability perspective has then also impacted the GVC research to some extent, expanding GVC analysis beyond merely economic and social issues to include greening processes (e.g. De Marchi et al., 2013a). Environmental sustainability and greening processes have however not received direct attention when analyzing chains and networks, as more focus has still been placed on economical values of capitalism production (Bush et al., 2015), resulting in several existing research gaps to fill, some of which will be further addressed below.

Alongside the increased attention to greening in the GVC literature, Wahl and Bull (2014) describe that the interest in private regulation initiatives within GVCs have gained momentum in recent years. Khemani and Shapiro (1993) state how regulations traditionally have been referred to as rules imposed by governments on companies. Nevertheless, regulation can also be adopted voluntarily by companies to maintain certain standards e.g. ethical or environmental (Khemani & Shapiro, 1993). Private regulation therefore refers to initiatives that are developed and administered by e.g. companies (such as lead firms) or other organizations within or connected to the GVCs (Wahl & Bull, 2014), in contrast to state regulation which are developed by e.g. states or governments. Private regulation when managed by lead firms can thus be somewhat equated with Gereffi's (1994) description of governance of GVCs. Furthermore, Wahl and Bull (2014) explain that the increased interest in private initiatives has risen from the limited impact of state regulations in complex and fragmented GVCs that stretch across national borders. However, there are still relatively few articles explicitly focusing on private regulation

in a GVC perspective considering the increased importance of these initiatives (Wahl & Bull, 2014). Consequently, this gives incentives to study governance within GVCs through a private regulation perspective further, rather than through external state regulations.

In a GVC context, private regulation initiatives to govern greening can be linked to sustainability governance. Sustainability governance from a top-down perspective has changed dramatically in recent years, as it has gone from lead firms operating reactively on environmental sustainability concerns up until the 1990s, to that lead firms started to proactively make their own greening initiatives within the organization by the mid 2000s (Ponte, 2019) e.g. through private initiatives. However, the GVC literature provides limited conceptualizations of adequate distinct modes of sustainability governance, where Bush et al. (2015) provide one of few. Overall, much focus of the research about greening of GVCs has been focused on the "lead firm" and its sustainability governance, or the internal organization itself, with a few exceptions investigating supplier motivations or impact (e.g. Ponte, 2019). This is further strengthened by the fact that the literature regarding greening of GVCs through environmental upgrading of suppliers from a bottom-up perspective is under-investigated (Khattak & Pinto, 2018). Also, environmental upgrading is a relatively new perspective to upgrading in GVCs, where De Marchi et al. (2010) is the first published article addressing the concept, followed by e.g. De Marchi et al. (2013);Khattak et al. (2015);Poulsen et al. (2018). Thus, it is interesting to investigate the influence and motivations of greening in GVCs not only from a lead firm perspective, but also include supplier impact and the dynamic between them as this has received modest attention in research.

As argued for above, the GVC literature has increasingly started to also include greening aspects. Nevertheless, there are still many aspects that have been overlooked, one of them being the negative environmental impacts of transportation (Golicic et al., 2010). Poulsen et al. (2016) and Poulsen et al. (2018) are some of few focusing directly on transportation when examining the dynamics between governance and upgrading in a greening of GVC perspective, however, focusing merely on maritime shipping. Surprisingly, no literature focusing on road transports in this context have been found, even though the road transport sector causes major CO2 emissions. Hence, the greening aspect of road transports in GVCs is especially interesting to examine further motivating the relevance of this study.

In summary, it is evident that the interest of greening and private regulation initiatives has gained an increased interest in the GVC literature. However, greening of GVCs through the lens of sustainability governance and/or environmental upgrading is still somewhat under-investigated, as many aspects have been paid limited attention. Specifically, greening of transportation has surprisingly been overlooked in a GVC context, despite its major cause of CO2 emissions. Therefore, this study attempts to address these issues by conducting a multiple-case study including several GVC actors within the chain, taking a dynamic approach of the top-down (lead firm) and bottom-up (supplier) perspective when analyzing greening of GVCs.

1.3 Purpose formulation

Based on the previously mentioned identified research gaps, the aim of this study is to gain a deeper understanding of how greening of GVCs is addressed within the chain by both lead firms from a top-down perspective and suppliers from a bottom-up perspective. The focus is on the reduction of CO2 emissions caused by road transports within the GVCs, with an emphasis on transitioning to fossil-free fuels.

1.4 Research question

Based on the ahead elaborations, the following research question have been formulated:

From both a lead firm and supplier perspective, how is greening of GVCs addressed by reducing CO2 emissions from road transports with an emphasis on fossil-free fuels?

1.5 Delimitations

Greening is a comprehensive term including several processes to reduce the overall environmental impact of a GVC. However, this study merely focuses on sustainability governance and environmental upgrading of road transportation as a means of greening GVCs through reduction of CO2 emissions with an emphasis on using fossil-free fuels. The three categories of fossil-free fuels that are covered in this study are biofuels, electrification and hydrogen. Furthermore, the study focuses mainly on how greening is performed and addressed by the actors within a GVC, and thus the impact of government regulation and external policies on greening in GVCs will not be thoroughly covered. Nevertheless, GVCs do not operate in isolation without any influence from external forces and therefore the study will to some extent touch upon how external forces can affect how actors within the GVCs behave. The nine GVC

actors included in this study consists of lead firms and different suppliers related to road transports, being road carrier, truck manufacturers and energy suppliers which was considered most relevant for this study.

2. Theory

The theoretical framework consists of a review of the GVC framework. Firstly, the terminology of GVCs and how it can be considered as a comprehensive term is discussed. Secondly, the two main research processes in the GVC framework are presented, being GVC mapping and GVC analysis. The presentation of the GVC analysis research process is divided into two parts; the first part presenting a background of the traditional view of governance and upgrading, whereas the second part focuses on greening of GVCs through sustainability governance and environmental upgrading. Thirdly, the role of inter-firm relationships is presented to consider the interconnection of the GVC actors. Lastly, this is summarized in a conceptual framework.

2.1 The Global Value Chain terminology

It has already been stated above that the world economy has gone through drastic change due to the rapid globalization process in the last few decades. To conceptualize the process of global economic fragmentation and integration in the 1990s, as well as the role of firms as lead actors, Gereffi (1994) formulated the framework of global commodity chains (GCC). Gereffi et al. (1994) defined GCCs as "*sets of interorganizational networks clustered around one commodity or product, linking households, enterprises, and states to one another within the world-economy.*" (p. 2). The aim of the development of the GCC concept was to slice through national boundaries when analyzing the global economy, to grasp a more comprehensive picture of the global production of commodities (Coe & Yeung, 2015). However, in the late 1990s it was found that the concept had several limitations (Coe & Yeung, 2015), which led to that the concept was refined, moving away from the concentration on commodities to focus on value added instead, and hence developed into Global Value Chain (GVC) analysis (Kano et al., 2020). Some scholars have argued that the shift from GCC to GVC was mainly terminological, whilst others (e.g. Ponte & Sturgeon, 2014) have stated that the two frameworks have significant differences where GVC is more focused on the complexity of information and value added along the chain, alongside with the involvement of human, natural and material capital in economic development (Bush et al., 2015). Nevertheless, it is evident that it is the GVC framework that has been used, applied in research and been further developed by scholars since then.

A conceptual framework which has also been developed in the early 2000s, with GCC/GVC as an important inspiration, is the Global Production Network (GPN) framework. In contrast to

the GVC framework, which has a disciplinary background in economic sociology, the GPN framework originated from the theoretical approach of economic geography (Kano et al, 2020). Ceo & Yeung (2015) defines GPN as "*an organizational arrangement, comprising interconnected economic and non-economic actors, coordinated by a global lead firm, and producing goods or services across multiple geographical locations for worldwide markets.*" (p.2-3). Thus, the GPN analysis does not only consider the single network itself, rather it includes the impacts of the geographic inter-connected locations and territories through the networks to extend to both intra-, inter- and extra-firm network analysis (Kano et al., 2020). Even though GPNs consider that firms are involved in inter-firm networks rather than linear chains, GVC is often seen as a more comprehensive concept, including a broader aspect of value added of fragmented activities and thus the GVC framework includes not only manufacturing activities (Kano et al., 2020). Moreover, Todeva and Rakhmatullin (2016) unites the two concepts by describing that *"Modern value chains are so complex that they are better described as value networks, or interconnected firms and value-added activities that integrate resource flows across manufacturing and service providers, pushing final outputs to markets."* (p.3). A summary of the differences between GCC, GVC and GPN is displayed in *Table 1* below.

	GCC	GVC	GPN
Disciplinary background	Economic Sociology	Economic Sociology	Economic Geography
Definition	"*sets of interorganizational networks clustered around one commodity or product, linking households, enterprises, and states to one another within the world-economy.*" (Gereffi et al., 1994, p.2)	*"the nexus of interconnected functions and operations through which goods and services are produced, distributed, and consumed on a global basis*" (Kano et al., 2020, p.579)	"*an organizational arrangement, comprising interconnected economic and non-economic actors, coordinated by a global lead firm, and producing goods or services across multiple geographical locations for worldwide markets.*" (Coe & Yeung, 2015, p.2-3)
Intellectual influences	World system theory International business Trade economics	GCC framework	Relational economic geography GCC/GCV studies

Table 1. Differences between GCC, GVC and GPN. Self-constructed table on the differences between GCC, GVC and GPN, based on Kano et al., (2020, table 1, p.581-582).

2.2 Mapping GVC

Frederick (2019) describes how the GVC framework is often divided into two equally important main research processes that lay the theoretical foundation being value chain mapping and value chain analysis. Mapping involves identifying the different actors within the GVC that are taking part in the chain from raw materials to finished products, e.g. firms, stakeholders, activities, suppliers and geographical locations (Frederick, 2019). Thus, the mapping process is determining who and what should be analyzed in the next step, namely the value chain analysis.

Frederick (2019) has established a general and industry neutral model for identifying all the structural parts of the chain, which can be seen in *Figure 1*. The model consists of four key parts, namely value-adding activities, supply chain, end markets and supporting environment, which are all essential for understanding the complexity of GVCs (Frederick, 2019). These can be performed in-house by the lead firm of the value chain, or by external suppliers through outsourcing or procurement. The value-adding activities in the GVC include six functions, from

the initial research and design development of the product, to manufacturing and distribution/logistics and lastly sales and aftermarket services (Frederick, 2019). The second part is the supply chain, consisting of four stages from inputs of raw materials and components, to outputs of finished goods and sales. Thirdly, the end market can function as an extension of the supply chain to understand the final customer characteristics, e.g. the B2B end market differs from B2C (Frederick, 2019).

The final part of Frederick's (2019) model is the supporting environment which considers external institutional actors at both local and global levels that creates the societal or legal parameters, influencing the participating actors in the GVC. However, dispersion and fragmentation are underlying logics of GVCs (Acquier et al., 2017). Thus, the impact of external institutional actors as state regulators in complex GVCs can be argued to be somewhat limited, which makes private regulation initiatives created by GVC actors within the chain more important (Wahl & Bull, 2014). Private regulation refers to initiatives that are developed and administered by e.g. companies (such as lead firms) or other organizations within or connected to the GVCs (Wahl & Bull, 2014).

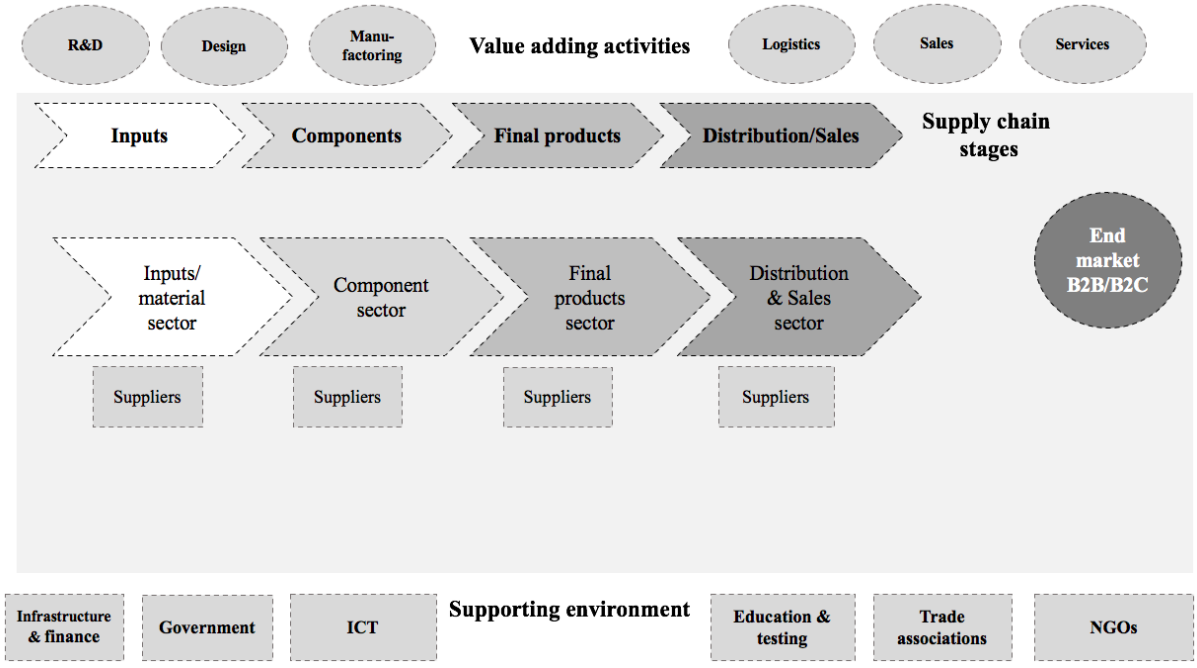

Figure 1. Self-constructed figure based on Frederick's (2019) model on mapping GVCs.

2.3 Presentation of the GVC analysis framework

After the GVC mapping process has provided an understanding of who and what should be analyzed, the next step is the GVC analysis (Frederick, 2019). The presentation of the GVC analysis is here divided into two parts, where the first part presents a background of the traditional view of governance, governance structures and upgrading. The second part instead focuses on specifically analyzing greening of GVCs through sustainability governance and environmental upgrading.

2.3.1 Background to analyzing GVCs

As mentioned in the introduction, Gereffi (1994) has established two contrasting ways to analyze GVCs being top-down (labeled "governance") and bottom-up (labeled "upgrading"), which will be discussed further in this section. However, it is important to note that even though these two concepts are presented separately, they are highly interconnected and should be used simultaneously to analyze GVCs. Khattak et al. (2015) describe this inter-connection by explaining how upgrading is an outcome of learning and innovation in the GVC, and learning is in turn affected by the governance structure and a result of interaction between actors in the chain and the lead firm. The type of governance structure can therefore affect the ability for actors to upgrade to a certain extent (Khattak et al., 2015).

2.3.1.1 Governance: the top-down approach

The top-down approach, labeled "governance", is related to the power of actors within and outside the chain to influence and control the activities in the GVC (Gereffi, 2011). In traditional management literature, power and control is generally viewed from an ownership perspective, where the organizations manage their internal units and employees within (e.g. Ouchi, 1979). Similarly, in the management literature on MNE headquarters-subsidiary relationship, top-down governance refers to the influence and control that the headquarters has on its subsidiaries, again having an intra-firm perspective (e.g. Ciabuschi et al., 2012). However, Kano et al. (2020) emphasize how coordination and control in GVCs can be achieved even though there is no direct ownership, which implies that governance also covers inter-firm relationships.

In a GVC perspective, states and institutions are possessors of power outside the chain, however, governance most often refers to "lead firms" (Khattak & Pinto, 2018). Lead firms can

be both producers or buyers in the chain who coordinate and control the activities of suppliers and other associated actors in the value chain (Gereffi, 2011). In producer-driven chains, lead firms act as producers that dominate and hold the power within the GVC and these chains are often present in industries that are characterized by high concentration of technological know-how and capital (Gereffi, 1994). On the other hand, Gereffi (1994) states that in buyer-driven chains, lead firms act as distributors and/or retailers of the final product and hold the power through strong brand names, often combined with outsourcing to achieve cost reduction while keeping quality and market proximity. The distinction between a buyer or producer lead firm can be used to understand the opportunity for suppliers to upgrade in the chain, as suppliers in buyer-driven chains hold much important competencies whilst the buyer is focusing on marketing and branding of the final product, giving suppliers in buyer-driven chains larger upgrading opportunities (Gereffi, 2011).

2.3.1.2 Governance structures

To include more complex products and increase the understanding of specific nodes and information flows within the chain, Gereffi (2011) extended the framework on governance by developing five structures of GVC governance: *market, modular, relational, captive and hierarchy* (Gereffi, 2011). The governance structures extend from *market governance* on one side of the scale, which involves easy information flows and arm's-length relationships, to *hierarchical governance* on the opposite side, which is predominated by vertical relationships, high managerial control with direct ownership of production processes (Gereffi, 2011).

In between the market and hierarchical governance, there are the three network governance structures. Network governance is a term which, according to Jones et al. (1997), is used *"to refer to interfirm coordination that is characterized by organic or informal social systems, in contrast to bureaucratic structures within firms and formal contractual relationships between them"* (p.913). Thus, network style governance does not imply any direct ownership, instead lead firms use coordination of production to exercise power (Gereffi, 2011). Therefore, the labeling of governance as "top-down" can be somewhat confusing in regard to the three network governance structures which are further described below, since it does not involve only vertical relationships and hierarchical power structures. The first network governance structure is *modular governance* which is the least common of the three styles of network governance and has only been identified in a few industries, primarily electronics (Golini et al., 2018). This governance structure occurs when standards are used for complex transactions, since the

information is somewhat easy to codify (Gereffi, 2011), where specifications are created by buyers on suppliers (Golini et al., 2018). Secondly, *relational governance* is a network style that includes more complex information transactions which are not easy to transfer and codify (Golini et al., 2018). Thus, this requires frequent interactions between buyers and suppliers, demanding for trust, mutual dependence and long-term relationships making the relationship-building time consuming and the cost of switching partners high (Gereffi, 2011). Lastly, *captive governance* is characterized by power asymmetry where the lead firm holds high power and controls the activities of suppliers. Suppliers are dependent on few buyers and thus the lead firm keeps a high degree of monitoring (Gereffi, 2011).

The five governance structures and their characteristics are summarized in *Table 2*. As seen in the table, the complexity of transactions (being the ability to transfer information) increases when moving on the scale from market governance towards hierarchical governance, whilst the capabilities of suppliers decrease following the same scale (Khattak et al., 2015). However, the ability to codify transactions is high for all governance structures except relational due to the higher complexity of transactions and lack of standards.

Governance type	**Market**	**Modular**	**Relational**	**Captive**	**Hierarchy**
Relationship buyer-supplier	*Arm's-length relationship*	*Buyer specifications on suppliers*	*Mutual dependency*	*Power asymmetry*	*Direct ownership*
Complexity of transactions	Low	High	High	High	High
Ability to codify transactions	High	High	Low	High	High
Capabilities of suppliers	High	High	High	Low	Low

Table 2. Summary of the five governance structures. Self-composed table based on Gereffi (2011, figure 2, p.43), displaying the five different governance structures and their respective level of transaction complexity, ability to codify information and the capabilities of suppliers.

2.3.1.3 Upgrading: the bottom-up approach

The other aspect of GVC analysis, the bottom-up approach, is referred to as "upgrading" (Gereffi, 1994). Bolwig et al. (2010) describe that "*In GVC analysis the concept of upgrading is used to identify the possibilities for producers to 'move up the value chain', either by shifting to more rewarding functional positions, or by making products with more value-added invested in them, and/or providing better returns."* (p.176). Hence, the traditional view of upgrading in GVC analysis is moving from low to high-value activities (Gereffi, 2011). This conventional view of upgrading is referred to as economic upgrading. However, scholars have enlarged this view by highlighting two additional types of upgrading, namely social and environmental (Barrientos et al., 2011; De Marchi et al., 2013b). Social upgrading includes the improvement of the labor conditions of workers in the chain, including increasing the quality of their employment and enhancing availability for better work opportunities (Barrientos et al., 2011). Nevertheless, the most under-investigated of the three is environmental upgrading (De Marchi et al. 2013b). De Marchi et al. (2013b) define environmental upgrading as *"the process by which economic actors move towards a production system that avoids or reduces the environmental damage from their products, processes or managerial systems."* (p.65).

As economic upgrading involves moving up the value chain, the focus of economic upgrading research is often suppliers in developing countries typically involved in low-value activities in GVCs (Khattak & Pinto, 2018). In contrast, environmental upgrading is an innovation process including gaining both technical and organizational knowledge to accomplish environmental goals (De Marchi & Di Maria, 2019), regardless of an actor's level of value added from its activities or its position in the GVC. For example, Poulsen et al.'s (2018) research on environmental upgrading has been carried out through studying ports in developed countries that are considered frontrunners in environmental management.

2.3.2 Analyzing greening of GVCs

Greening should be understood as improving the environmental performance of e.g. an actor or a process (Poulsen et al., 2018). To understand the greening process of GVCs, one should as previously emphasized include both the top-down and bottom-up perspective as there is a dynamic interaction between the two perspectives (Khattak et al., 2015). Therefore, analyzing greening of GVCs covers both sustainability governance and environmental upgrading.

2.3.2.1 Sustainability governance

Governance of GVCs can further be used to influence greening of the chain, which is referred to as sustainability governance. Sustainability governance in a GVC perspective relates to lead firms influencing and controlling the various practices, activities as well as organizational and management structures that foster greening of the GVC (Bush et al., 2015). However, sustainability governance has been somewhat neglected in the GVC literature. With the aim to fill this gap and develop a better understanding of sustainability governance in GVCs, Bush et al. (2015) have established a typology of three modes for identifying how sustainability is governed in chains by both firms and non-firm actors. These are governing sustainability *in* chains, governing sustainability *of* chains and governing sustainability *through* chains, where the first two have an internal perspective and the last one has an external perspective to the GVC. Governing sustainability *in* chains is mainly mentioned in business management literature that analyzes environmental management, and has a heavy focus on management and their receiving of performance indicators of actors in the chain to effectively control the environmental impact of suppliers through e.g. environmental ISO certifications (Bush et al., 2015). Governing sustainability *of* chains, on the other hand, refers to lead firms setting standards to drive change among the actors in the chain. The lead firms also transfer the necessary knowledge and technology needed to improve the sustainability performance of their suppliers, focusing more on coordination mechanisms and power structures among chain actors (Bush et al., 2015). Lastly, governing sustainability *through* chains moves beyond the internal chain coordination as it includes horizontal connections. Thus, it encompasses a broader scope and includes the interaction of internal and external actors of the chain and how they influence sustainable consumption and production of the chain but also beyond it (Bush et al., 2015).

Other scholars discussing sustainability governance are De Marchi et al. (2013a). In their study, two approaches are established on how to govern the greening of GVCs, namely standard-driven greening and mentoring-driven greening. The former refers to lead firms establishing environmental standards, and what environmental impacts should be targeted. The standards affect both the selection of new suppliers, as well as existing suppliers (De Marchi et al., 2013a). In contrast, mentor-driven greening is rather built upon personal interactions between the lead firm and its suppliers, where they contribute with skills and knowledge (lead firms with environmental, and suppliers with technical). Further, De Marchi et al. (2013a) found that when governing the greening of GVCs, lead firms have a critical role. However, when doing so they

also aim to engage deep relationships with suppliers, especially if the greening holds a key competitive advantage (De Marchi et al., 2013a).

2.3.2.2 Environmental upgrading

As described above, the greening process of GVCs is not only top-down vertical governance. De Marchi & Di Maria (2019) stress that moving beyond the top-down governance perspective is necessary to seize the rationale for firms to work towards being more environmentally sustainable and the opportunities for it to spread in the GVC. Thus, environmental upgrading also includes how other actors, e.g. suppliers, can approach sustainability bottom-up, gaining competitive advantage to upgrade in the GVC (Havice & Campling, 2017;De Marchi et al., 2013b). Achieving environmental upgrading by a firm to address environmental goals can be seen as an innovation process where new organizational and/or technical knowledge is developed and used (De Marchi & Di Maria, 2019). Environmental upgrading of GVCs can be both reactive and/or proactive, where the former refers to actions based on e.g. customer demands or regulation response and the latter refers to actions based on e.g. greening strategies, energy optimizations, brand repositioning and new product/service development (Poulsen et al., 2018). The drivers for actors in the GVC to work with greening can be both internal and external, where internal drivers include more proactive actions whereas external drivers include more reactive actions as a result of market demands and stakeholder requests (De Marchi & Di Maria, 2019). According to De Marchi and Di Maria (2019), the external drivers support firms to perform investments in regard to greening in a more reactive manner, however, the motivation might be weaker in comparison to internal drivers. Nevertheless, when performing a comprehensive analysis, the internal/external drivers should be considered in a complementary and simultaneous manner (De Marchi & Di Maria, 2019).

Furthermore, environmental upgrading can be buyer-driven, which means that buyers (often lead firms) ask questions regarding environmental performance of the supplier (Ponte, 2019;Wolf & Seuring, 2010). Ponte (2019) exemplifies this in a cargo owner-carrier (i.e. buyer-supplier) context where questions from the buyers have mainly focused on lowering emissions and fuel efficiency of the supplier. However, buyers have not yet established well-developed environmental demands for carriers, and these demands are often not integrated in the procurement of the transport (Ponte, 2019). This is further emphasized by Wolf and Seuring (2010), who describe that buyers often lack the ability to integrate logistics and transportation into their environmental strategy, which result in environmental performance having low or no

influence on the contracting. This ambiguity can lead to buyers setting lower environmental requirements for the supplier than the supplier is de facto able to perform (Wolf & Seuring, 2010), or that suppliers only perform environmental measures that can lead to own cost-savings (Ponte, 2019). Another aspect limiting buyer-driven environmental upgrading of suppliers is the absence of consistent and standardized measurements of CO2 emissions, since it inhibits buyers from having credible data on performance and to make benchmarking comparisons (Poulsen et al., 2016).

Moreover, Poulsen et al. (2016) have found that lead firms operating B2C more often enhance suppliers' likelihood to environmentally upgrade than non-consumer facing lead firms, as the B2C companies face higher reputational risks. Nevertheless, Khattak et al. (2015) highlight the critical role of suppliers in the environmental upgrading process, alongside with the role of lead firms and buyers. When it comes to suppliers and their ability to drive environmental upgrading, the GVC literature has given little attention to suppliers working as proactive actors within the chain (De Marchi & Di Maria, 2019). Suppliers have their own autonomy, not necessarily driven by lead firms, to work proactively to create sustainable strategies and modify their product/service offering to attain a higher value in the chain (De Marchi & Di Maria, 2019). For suppliers to succeed with environmental upgrading, crucial factors are their own strategic intent, capabilities and competencies, apart from the support of lead firms (Khattak et al., 2015).

2.4 The role of inter-firm relationships in GVCs

As previously mentioned, it is important to note that modern GVCs include not only linear processes and relationships, but also complex interconnected firms and networks (Todeva & Rakhmatullin, 2016). Furthermore, firms have become more dependent on their relationships with suppliers as in today's business environment competition occurs between GVCs rather than between individual firms (Ilyas et al., 2007). Thus, the statement by Håkansson and Snehota (1989) that *"no business is an island"* is also highly relevant in this context. According to Holm et al. (1999), fast and continuous development of technology calls for heavy resources from both supplying firms and buying firms, where they mutually must commit long-term to develop together. By interacting in business network relationships, actors are enabled to earn greater value compared to if they would have not committed to relationship development (Holm et al., 1999). Kanter (1994) further strengthens that good relationships through collaboration have become an important asset for companies, as the ability to create and maintain successful

collaborations (i.e. collaborative advantage) gives companies an important competitive benefit. To create a collaborative advantage and earn greater value through inter-firm collaborations, Ilyas et al. (2007) outline three cornerstones that must be met. These three cornerstones are compatibility (e.g. unified strategic vision, finances and policies on ethics), capability (e.g. competence and complementary strengths) and commitment (e.g. core activity and exit cost) (Ilyas et al., 2007).

2.4.1 Inter-firm relationships to perform greening in GVCs

Successfully achieving greening in a GVC is a major challenge. Implementing new green strategies in the GVC has been proven to require close coordination and agreements between the actors within the chain, which is in direct contradiction of the underlying logics of GVCs (Acquier et al., 2017). De Marchi et al. (2013a) emphasize that long-term relationships, trust and a stable demand are critical to facilitate greening of suppliers. In addition, Wolf and Seuring (2010) describe how integration, information sharing as well as cooperation have been stressed as important factors for successful inter-firm relationships to increase supplier's environmental performance. Furthermore, the realization of greening of an entire chain requires cooperation between environmental conscious suppliers and the lead firm of the chain (Wolf & Seuring, 2010). This is also supported by De Marchi et al. (2013a) who highlights that cooperation in regard to innovation between a lead firm and its suppliers has a positive impact on the development of green offerings. Cooperation is also required to overcome heavy transaction costs which are often higher for green than non-green products (De Marchi, 2013a).

Another increasingly important aspect of relationships within GVCs are cross-sector partnerships with other actors in the VC, e.g. universities and non-governmental organizations (NGOs), to share and create environmental knowledge and mutually develop greener offerings (De Marchi et al., 2013b). These cross-sector partnerships vary in content and scope; however, their basic preconditions are often the same (Bitzer & Glasbergen, 2015). Bitzer and Glasbergen (2015) emphasize that the cross-sector partnerships are based on the utilization of complementary capabilities and resources of the different parties to jointly address issues that would otherwise not be possible by a single party. Larger cross-sector partnerships that are governed by both commercial/non-commercial and governmental/non-governmental stakeholders can also work as a steering mechanism to set voluntary rules for sustainability for the actors involved (Ponte, 2019).

2.5 Conceptual framework

To examine how greening of GVCs is performed, a conceptual framework has been created, which is illustrated in *Figure 2*. The model is based on the GVC frameworks' two main research processes: GVC mapping and GVC analysis.

Firstly, the mapping process (marked in bold dots in *Figure 2*) lays the foundation for which actors should be analyzed in the next step, namely the GVC analysis. Secondly, the GVC analysis builds on two different approaches: top-down and bottom-up illustrated by the two triangles in *Figure 2*. The top-down analysis covers how lead firms govern suppliers and activities (i.e. governance) and specifically greening (i.e. sustainability governance) in the GVC. The bottom-up analysis includes how suppliers work towards being more sustainable (i.e. environmental upgrading). However, it is important to note that even though the top-down and bottom-up approach are two separate approaches, they are highly interconnected and are therefore used simultaneously to analyze GVCs.

Lastly, in line with Kano et al. (2020), the term GVC will be used in an inclusive manner in this thesis to capture the aspect of value added, and thus include not only internal manufacturing activities but also outsourcing of knowledge-intensive activities that are not necessarily linked to production. However, the network perspective, which is central within the GPN framework, has not been completely neglected. As argued by Håkansson and Snehota (1989) *"no business is an island"*, meaning that one should not consider organizations as free and independent individuals, rather they are embedded in its environment and interconnected with other actors through relationships. Therefore, the role of inter-firm collaboration between different actors for greening of GVCs has also been considered in the conceptual framework at the top of the triangles, marked with a dotted oval in *Figure 2*, which unifies the top-down and bottom-up approach.

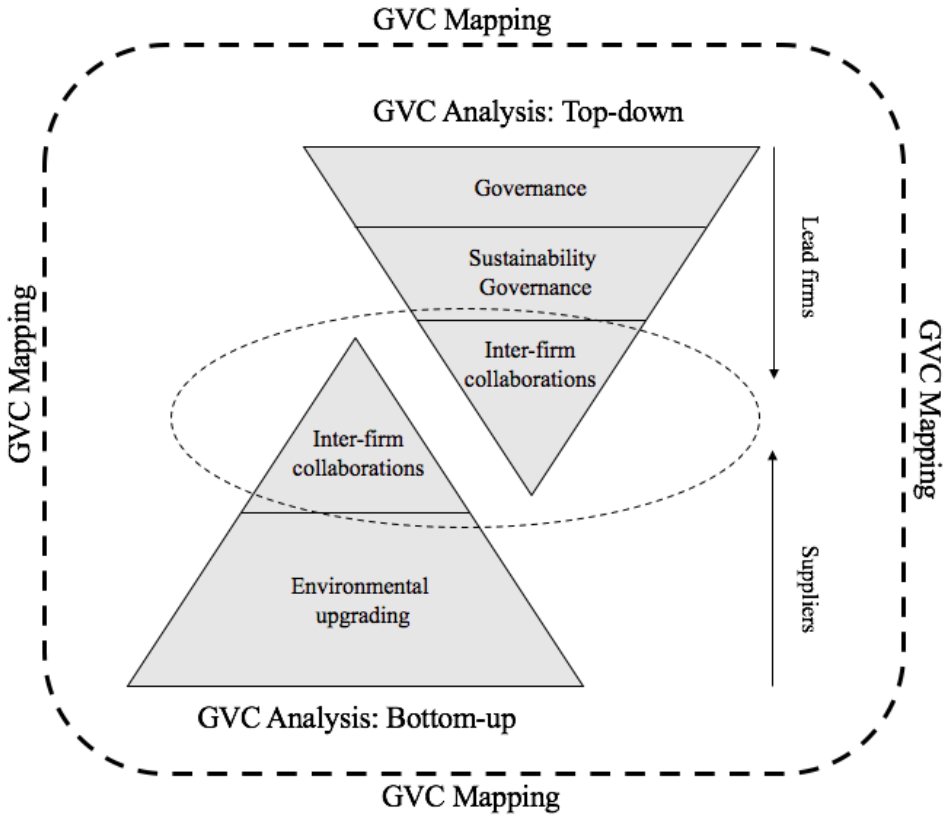

Figure 2. Self-constructed conceptual framework model compiled by authors.

3. Methodology

The methodology chapter presents and explains the motivations behind the choice of methods used in this study. Firstly, a description of the research method and approach is presented, followed by an outline of the sampling of case companies, data collection and data analysis. Lastly, quality and ethical considerations are presented to provide a critical reflection of the methodology choices.

3.1 Qualitative research method

According to Bell et al. (2019), the research method should be decided based on the research question that the study attempts to answer. For this study, the research question is "*From both a lead firm and supplier perspective, how is greening of GVCs addressed by reducing CO2 emissions from road transports with an emphasis on fossil-free fuels?*", taking an explanatory approach to "how" rather than answering more quantitative questions as "how much" or "how many". Therefore, in accordance with Eriksson and Kovalainen (2008), the formulation of the research question of this study speaks in favor of using a qualitative research design as we aim to grasp a deeper understanding of the greening of GVCs. The qualitative method takes on a people perspective, where the social world is described according to the perspective of the studied people (Bell et al., 2019). Furthermore, the qualitative research approach aims to provide a holistic understanding of the reality through interpretations (Eriksson & Kovalainen, 2008), as well as underlying patterns and the experiences of the study objects (Patel & Davidsson, 2011), in our study covering both the perspective of lead firms and suppliers. Hence, to understand how greening of GVCs is addressed through reducing CO2 emissions from road transports, subjective perceptions were regarded highly relevant to describe social and relational settings between the GVC actors motivating the choice of a qualitative research method.

3.2 Abductive research process

When conducting a study, one has to decide on the relationship between theory and empirical findings and therefore choose between a deductive, inductive or an abductive approach (Patel & Davidsson, 2011;Bell et al., 2019). This study has taken an abductive approach, since we have moved between the deductive and inductive approach where the theoretical perspective has been continuously developed and extended based on empirical evidence. The selection of an abductive research approach is further strengthened by Dubois and Gadde (2002) who states

that *"theory cannot be understood without empirical observations and vice versa"* (p.555), meaning that theory and empirical findings should be considered simultaneously.

As this study's data collection is built on a qualitative case study approach (see *3.3 Case studies*), an abductive approach through a systematic combining of theory and empirical findings was considered suitable, as it according to Dubois and Gadde (2002) enables comprehensive descriptions that move beyond the traditional linear process of case studies. Initially, this study took a deductive approach which according to Patel and Davidsson (2011) is based on "what is known in theory", where theory and common principles are reviewed and thereafter applied on the result of the research to find connections and draw conclusions based on them. Thus, existing literature was first gathered and reviewed to create a solid theoretical ground on prior research on GVCs, GVC analysis and greening processes of GVCs. The initial literature review was also used to identify relevant study objects and formulate the interview questionnaires used in the empirical data collection. The study then took an inductive approach, which according to Patel and Davidsson (2011) is based on empirical data, and thus the researcher aims to create theory from the observations (Bell et al., 2019). Thereby, additional insights were made from the empirical data collection leading to modification and development of the already established theoretic framework. For example, the empirical data collection provided insights in the importance of inter-firm relationships to perform greening in GVCs, which was then added to the theoretical framework. In result, a conceptual framework was compiled based on both theoretical and empirical evidence.

3.3 Case studies

Yin (2018) describes that case studies are a useful and popular qualitative research method within the field of International Business when the research question has an explanatory approach, as in this study. The aim of a case study is to enhance a detailed and in-depth analysis of a single case, and it also enables researchers to grasp complex issues which they have no or little control over (Bell et al., 2019). This study aims to analyze GVCs, known to be complex, dispersed and fragmented in their nature. These characteristics also lead to that all GVCs tend to be unique depending on the lead firm, the industry in which it operates and the other participating actors in the GVC, amongst others. Hence, to grasp the uniqueness of GVCs, a multiple-case study including four lead firms and their respective GVC related to road transport were conducted. Further, to also grasp the participation of suppliers in GVCs and thus also

consider the bottom-up perspective, five suppliers related to road transport were also included. This resulted in a multiple-case study of nine GVCs actors to enable a dynamic analysis. A multiple-case study design was further considered most suitable since it according to Bell et al. (2019) enables studying multiple cases to compare and contrast the findings to see what is overlapping between cases and what are unique and non-generalizable findings. Furthermore, multiple-case studies are often considered more robust and compelling, as it is based on evidence from multiple cases (Herriott & Firestone, 1983), adding additional arguments to the use of a multiple-case study design in this study. However, when conducting a multiple-case study there are different quality aspects that have to be considered which is further described below (see *3.6.2 Validity*).

3.4 Data sampling

Before collecting primary data through interviews, a selection of respondents was made. According to Bell et al. (2019) the selection of respondents can be made through probability sampling meaning that the sampling is random, or through non-probability sampling which means that the sampling is not random and therefore subjective. In this study, purposive sampling has been used, which according to Bell et al. (2019) is a non-probability form of sampling. Bell et al. (2019) states that *"the goal of purposive sampling is to sample cases/participants in a strategic way, so that those sampled are relevant to the research questions that are being posed*" (p.389). Thus, to sort out the most relevant case companies to the study, a set of criteria was developed. For this study, respondents representing four lead firms and five suppliers consisting of one road carrier, two truck manufacturers and two energy suppliers which are all related to road transportation in GVCs were included. The criteria varied depending on the actor as follows:

> **Lead firms:** (1) had to be categorized as an MNE, thus having global presence and operation in more than one country, and (2) having official corporate environmental sustainability goals including transports.
>
> **Road carrier:** (1) had to be categorized as an MNE, thus having global presence and operation in more than one country, and (2) using fossil-free fuels within their fleet.
>
> **Truck manufacturers:** (1) had to be categorized as an MNE, thus having global presence and operation in more than one country, and (2) having an ambition to produce, or already produce, trucks driven by fossil-free fuel.

Energy suppliers: the only criterion was that we wanted to include one traditional energy supplier and one merely focusing on supplying fossil-free fuels to be able to compare findings.

It was also decided that Swedish case companies were most convenient to contact, as we are more familiar with Swedish businesses and Swedish companies were deemed to have a higher chance of being positive to participate in the study. To initiate contact with potential respondents, we followed the set criterions and formulated a list of companies of interest. Then employees with a more strategic role within the companies were contacted through email, as they were considered to possess the specific expertise and knowledge required to answer the interview questions. In the email, the potential respondents were provided with background information, the purpose of our study and the time plan for the interview. This is in line with Bell et al. (2019) who highlight the importance of the respondent to be aware of the interview schedule beforehand. If the contacted employees did not consider themselves suitable to contribute to the study, they were requested to forward the email to a better suited respondent. This is referred to by Jacobsen et al. (2002) as snowball sampling, which has been used in addition to the purposive sampling method. In this way, we ensured the most appropriate respondent possible to represent the GVC actors for this study.

3.5 Data collection

When conducting a case study on a social phenomenon it is preferred to use multiple sources and methods to collect data (Bell et al., 2019). Further, the ability to handle a variety of sources of evidence is one unique strength of case studies (Yin, 2018). In this study, sources of evidence have been collected from a combination of qualitative interviews and other documents.

3.5.1 Interviews and questionnaire design

Interviews are among the most important sources of evidence in a case study (Yin, 2018), and thus it is the main source of evidence in this study. In qualitative interviews, the focus is on the respondent's point of view and opinions (Bell et al., 2019), and it also provides high flexibility since the respondents can answer with their own words. Bell et al. (2019) present semi-structured interviews as an approach for how qualitative interviews can be conducted, where an interview guide is prepared in advance with questions on the topic that can be asked in a predetermined order, or the order can be changed throughout the interview. In this study, semi-

structured interviews were considered the most suitable method to cover the necessary themes of the interviews, but still allow for some flexibility depending on the answers of the respondent. In line with this, four different interview guides tailored for lead firms, the road carrier, truck manufacturers and energy suppliers were prepared prior to the interviews. The questions in the interview guides had a predetermined order and can be found in *Appendix 1* in both a Swedish and English version, however the order of the questions was adjusted during the interview according to what was considered appropriate and follow-up questions were asked to clarify and develop certain answers. The identified theoretical themes from the initial literature review gave support in formulating the interview guides. For lead firms the identified themes were GVC mapping and greening of road transport, whereas for road carriers, truck manufacturers and energy suppliers the identified themes were greening of road transport and transition to fossil-free fuels. All interview guides had a last question that gave an opportunity for the respondents to clarify or add to what had been answered during the interview. After each interview the two authors discussed each interview to summarize the general themes and main points of the interview to reflect on the procedure and develop a common understanding between us.

Bell et al. (2019) further suggests recording as a tool to document what the respondents said in the interview and it also helps the interviewer to pay attention to what is being said and not be distracted by taking notes. Therefore, the interviews were recorded and transcribed with permission from the respondents to capture the respondents' own words. However, recording has some disadvantages, e.g. it can result in the respondents giving more thoughtful answers due to the possible concern that the material will be saved (Bell et al., 2019). Nevertheless, to minimize this inconvenience the respondents were clearly informed that the recordings were only used for transcribing and that they would be provided with the compiled empirical material for approval. To further minimize potential other inconveniences, research ethical principles have been considered (See 3.7 *Ethical considerations*).

3.5.2 Respondents and interview setting

As visualized in *Table 3*, nine interviews were conducted between 12th of March and 16th of April 2021, and the interviews lasted for 30-55 minutes. All interviews were carried out in Swedish, since it is the native language of the interviewers and all the respondents. In addition, it was considered important that the respondents were comfortable to answer without any language barriers. The compilation of the interviews was written in English in the empirical

chapter and the selected quotations were translated by the authors. The translated and compiled draft for each case company was then sent to the respective respondents to ensure that a correct translation and interpretations had been made of their answers. A few modifications or clarifications were made for some drafts based on the comments from some respondents. After that, all drafts were accepted. One of the respondents requested to be anonymized, thus, CompanyX was used as a fictitious name for the case company and RespondentX was used as a fictitious name for the respondent.

GVC Actor	Company name	Industry	Respondent name	Position	Date	Interview length
Lead firm	CompanyX	Manufacturer of consumer products	RespondentX	Sustainability Developer	16th of March 2021	40 min
Lead firm	Lidl Sweden	Food & Groceries	Carl Ceder	Head of Logistics	17th of March 2021	35 min
Lead firm	SCA	Forestry & Paper	Magnus Svensson	President Sourcing & Logistics	19th of March 2021	45 min
Lead firm	Essity	Hygiene & Health	Maria Mollberg	Director Sustainable Sourcing	23rd of March 2021	55 min
See above (s.a)	*s.a*	*s.a*	Sofie Kaltenbach	Distribution Manager	*s.a*	*s.a*
Road carrier	DB Schenker	Logistics	Hanna Melander	Quality & Environmental Manager	26th of March 2021	30 min
Truck manufacturer	Volvo Trucks	Vehicle manufacturing	Lars Mårtensson	Environmental & Innovation Director	12th of March 2021	40 min
Truck manufacturer	Scania	Vehicle manufacturing	Magnus Fröberg	Technical Manager Fuels	22nd of March 2021	45 min
Energy supplier	Preem	Fuel & Energy	Peter Abrahamsson	EVP, Sustainable Development Director	15th of March 2021	30 min
Energy supplier	Econ	Fossil-free fuel provider	Morgan Larsson	CEO & Founder	16th of April 2021	40 min

Table 3. Overview of interviews.

The interviews were held in an online setting, where both authors were present, and cameras were used by all participants to allow face-to-face interaction. The main reason for the interviews being carried out digitally was to ensure ours' and the respondents' safety due to the current Covid-19 pandemic, and thus eliminating the transmission risk. However, digital meetings also have additional advantages. Bell et al. (2019) describes that it is more flexible, more convenient and timesaving than physical face-to-face interviews. For this study, the digital interviews made it possible to include respondents regardless of their geographical location due to eliminating the time and cost to travel. Furthermore, Bell et al. (2019) also describes some limitations of digital interviewing, e.g. disturbing situational factors such as technological problems. Nevertheless, no major disturbing inconveniences affecting the quality were experienced when conducting the digital interviews for this study. As seen in *Table 3*, two respondents were interviewed at the same time for one of the companies. The respondents however work within different business units with no power imbalance between the two respondents, meaning that they are colleagues at similar company level.

3.5.3 Documents and secondary data sources

As mentioned above, the interviews were complemented with secondary data sources consisting of the lead firms' annual reports, sustainability reports and supplier Code of Conducts. The documents were used to get a deeper and broader understanding of their GVCs, which was especially useful since the interviews were conducted with lead firms being MNEs and only with one or two respondents from each case study object. Thus, it can be difficult for a single respondent to provide a holistic view of the entire MNE and its process. Furthermore, these sources also worked as a tool to verify the empirical data received from the interviews (see triangulation in *3.7.2 Validity*).

3.6 Data analysis

As described in Chapter 3.2 *Abductive research approach*, this study has taken an abductive approach to answer the research question "*From both a lead-firm and supplier perspective, how is greening of GVCs addressed by reducing CO2 emissions from road transports with an emphasis on fossil-free fuels?*", where the theoretical framework and the empirical findings have been handled in an interplay to create conditions for a thorough analysis. The data analysis was carried out by using pattern matching of theory and empirical findings, which according to Yin (2018) is a desirable technique for case study analysis. Pattern matching involves

comparing a theoretical predicted pattern with an empirically observed pattern (Trochim, 1989). The GVC mapping of the empirical findings was carried out based on the theoretical GVC framework related to mapping, hence, as illustrated in *Figure 3*, a pattern matching between theory and empirical findings was conducted. The GVC mapping was performed to demonstrate an overview of the supply chain stages and road transports between them in the lead firms GVCs, as well as who controls them. Furthermore, the GVC mapping then provided a basic outline for the GVC analysis of how the various actors work with greening of road transportation both internally and in collaboration with other actors, which was then matched in relation to the conceptual framework in Chapter 5 *Analysis*. The conceptual framework (found in Chapter 2.6 *Conceptual framework*) consists of parts of the GVC theoretical framework in addition to the role of inter-firm collaboration in GVCs.

To enable the GVC analysis of greening and a comparison between the GVC actors within a specific category (e.g. lead firm vs. lead firm) but also between the categories (lead firms vs. road carriers vs. truck manufacturers vs. energy suppliers), a cross-case analysis was used as an analytical tool, as seen in *Figure 3*. The cross-case analysis included all nine GVC actors covered in this thesis, where the empirical findings were coded to identify similarities and differences between the cases. The coding was systematically conducted through identifying information and quotes that were grouped into different themes. An example of how the cross-case analysis between the cases was done can be found in *Appendix 2*. Furthermore, the cross-case analysis was performed to extend the understanding beyond the single actor and reveal new dimensions, in accordance with Khan and VanWynsberghe (2008). This facilitated answering the research questions and concluding how greening of road transports is performed in GVCs from a top-down and bottom-up approach. In *Figure 3*, a summary of the data analysis process is displayed.

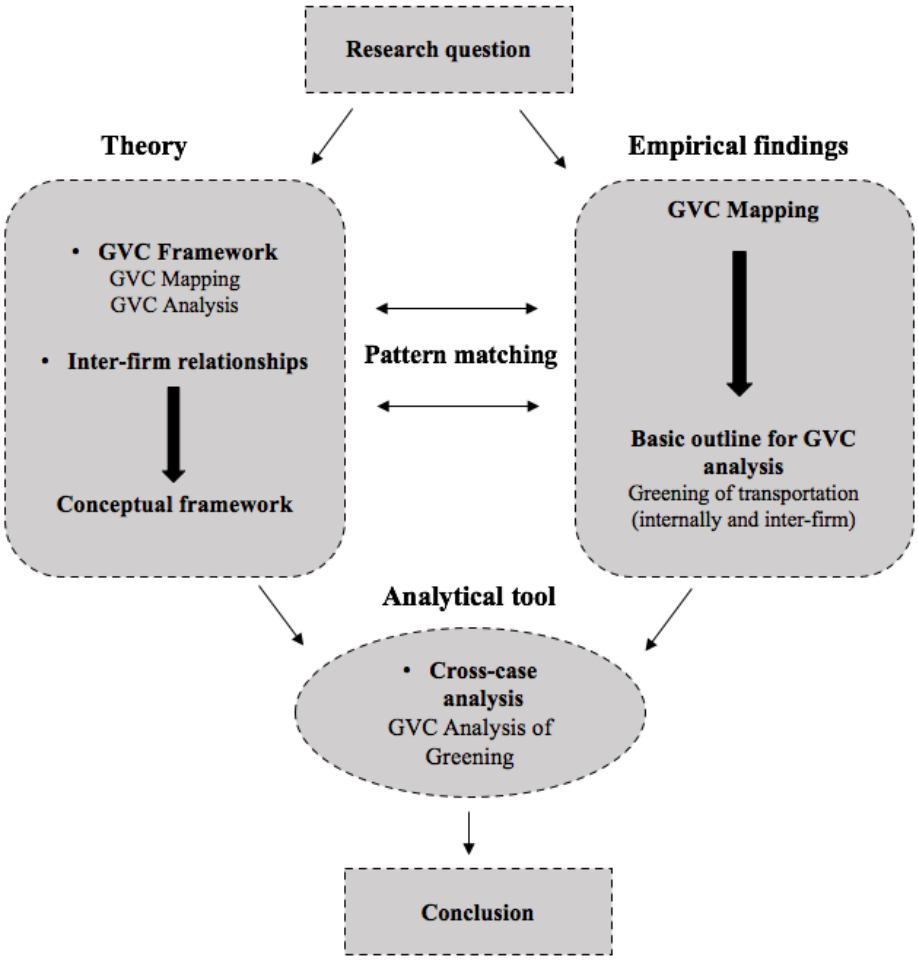

Figure 3. Data analysis model. Self-constructed analysis model for this thesis, based on the pattern matching logic.

3.7 Quality Criteria

To ensure high quality of the gathered empirical data and to secure the information that was later used for the qualitative analysis, quality criteria were considered. However, Bell et al. (2019) argues that when conducting a qualitative study, the relevance of quantitative criteria as reliability and validity could be questioned, as these usually rely on measurement and objectivity which are both uncommon phenomena in qualitative research. Instead, the criteria need to be adapted for qualitative methods (Bell et al., 2019), which in this study have been done by using four tests presented by Yin (2018); *reliability*, *construct validity*, *internal validity* and *external validity*.

3.7.1 Reliability

Reliability relates to the repeatability of the results from a study, meaning that another researcher would be able to conduct the same study and arrive at equal conclusions (Yin, 2018). To increase the repeatability, the authors should carefully document the research procedure (Yin, 2008) meaning that all material gathered during the research process of the study is kept and can be accessed by others if desired (Bell et al., 2019). Following these recommendations, all material collected during the process of this study, from decisions regarding selection of research subject to research participants and interview transcripts have been carefully kept and stored. Nonetheless, it is worth noting that the exact replication of a particular case study is rarely feasible due to the changing nature of social settings (Yin, 2018), and as it includes studying human behavior which is never static (Merriam, 1995). To however approach the possibility of replicability and to give an understanding of the cases, descriptions of the specific settings during the interview sessions have been noted and are outlined in Chapter 3.5.2 *Respondents and interview setting*. In addition, the methodological choices of this thesis have been clearly described and motivated by for example illustrating the dynamic interplay between theory and empirical findings in Chapter 3.2 *Abductive research process*, and a detailed description of the data analysis process in Chapter 3.6 *Data analysi*s. This has a positive impact on the replicability of the study as it enables the reader to understand how we arrived at our results.

3.7.2 Validity

Validity assesses how well the study measures, observes or identifies what it is intended to do (Bell et al., 2019). Yin (2018) divides the concept of validity for qualitative case studies into three criteria: *construct validity*, *internal validity* and *external validity*.

Firstly, construct validity concerns the data collection and compilation of the study. Yin (2018) describes how case study researchers can be accused to only see what they want to see, questioning the level of construct validity. To avoid such inconveniences, triangulation of the collected data has been made. Triangulation refers to using multiple sources of data and can be used to cross-check findings from studies (Bell et al., 2019). For this study, triangulation was used to cross-check and verify the empirical data from the interviews by studying company annual and sustainability reports, and other company documents as e.g. supplier Code of Conducts. Thus, the interviews were complemented with secondary data and other documents. Another way to increase the construct validity is to let key informants review the draft of the

case study (Yin, 2018). Bell et al. (2019) refers to this as respondent validation, which means that the researcher provides the respondents with the findings to enable the respondent to give feedback and correct misunderstandings. This was done by providing all respondents with the compiled empirical version of the interview over email to give the respondents the possibility to confirm or modify what had been said to avoid any misinterpretations of the empirical data during the analysis.

Internal validity is applicable to explanatory studies and refers to the attempt to establish causal relationships that are not influenced by spurious effects (Yin, 2018). The goal is to assure that one's findings are coherent with reality, which in qualitative research is assumed to be constructed and multidimensional (Merriam, 1995). According to Merriam (1995) it is important to note how the researchers' own experiences and biases can affect the study. However, findings have been handled, discussed and analyzed by both authors and peer-reviewed by a third-party supervisor to increase the internal validity. Furthermore, the assurance of internal validity in a case study is, according to Yin (2018), carried out in the analytical phase and the author suggests *pattern matching* as one useful analytical tactic. In this study *pattern matching* has been used as an analytical technique which is further described in the previous Chapter 3.6 *Data analysis*.

Lastly, external validity focuses on the generalizability of the case study (Yin, 2018), i.e. to what extent the results could be applicable to other situations and research namely the level of transferability (Bell et al., 2019). As the data in this study are conducted from a non-probability sampling of Swedish firms operating in a specific context, the transferability can be questioned. This issue has been handled by applying the recommendation of Guba and Lincoln (1994), that suggests including thick descriptions of details regarding the setting and environment where the firm operates, since it allows for external judgements of the transferability level of the empirical findings to other situations. Furthermore, as emphasized by Merriam (1995): "*The goal of qualitative research, after all, is to understand the particular in depth, rather than finding out what is generally true of many.*" (p.57). For this study, it means that even though a smaller sample of case study objects have been used, the participants have been chosen for their specific position at the company and their expertise and knowledge related to the research question. In result, an in-depth understanding of the specific GVCs and how greening is addressed has been accomplished. In addition, even though all interviewed case companies are

Swedish, the companies have a global presence and the questions have regarded global rather than local issues resulting in higher transferability of the results.

3.8 Ethical considerations

According to Bell et al. (2019) there are four ethical principles that have to be considered while conducting business research that concern how the participant of the interview is treated so that it does not lead to any negative consequences. The four ethical principles are presented below together with how they have been considered in this study.

I.) **Harm to participants**: Due to the transmission risk of Covid-19, the interviews were held on Zoom.

II.) **Lack of informed consent**: The respondents were all informed about the research process, the purpose of the research and other information needed to make a decision to participate in the study or not.

III.) **Invasion of privacy:** The respondents were given the opportunity to remain anonymous in the study. Also, the respondents were welcomed to use a background filter during the interviews on Zoom to not invade their privacy.

IV.) **Deception:** All respondents were informed about the study and the purpose of it.

4. Empirical findings

The empirical findings firstly present an outline of fossil-free fuel alternatives to create a basic understanding of certain reasonings of the field in the empirical data. Secondly, the empirical findings are divided into lead firms, road carrier, truck manufacturers and energy suppliers, representing the actors in GVCs connected to road transportation of goods. For lead firms, an overall mapping of suppliers and transports in their GVCs are carried out to provide an overview of how the lead firm governs its GVC. The mapping then lays the foundation to provide a basic outline for the analysis of all GVC actors covered in this thesis, and how they work with greening of transportation both internally and in collaboration with other actors. Lastly, three tables summarizing the empirical findings of the lead firms, as well as the road carrier, truck manufacturers and energy suppliers are presented.

4.1 Fossil-free fuel alternatives

Fossil-free fuels are made from renewable energy sources that naturally replenish themselves such as wind, hydropower or biomass (European Commission, 2021). The three fossil-free fuel alternatives for road transports that were mentioned during the interviews (being biomass, electrification and hydrogen) are presented below to provide the reader with a basic understanding of their general characteristics.

Biomass, which is used for the production of biofuels, is made from organic resources such as waste from plant-based materials from agriculture, forestry, and industry (Wee et al., 2012), which makes it cost effective compared to other fuels. Additionally, biofuels can be used in existing vehicles and refueling systems, which have lowered its entry barriers and increased its maturity level for road transports. Examples of biofuels are ethanol, biodiesel (e.g. HVO and RME) and biogas (Riksdagen, 2017). However, it has been stated that today's energy and fuel consumption is too high to be replaced by purely biomass/biofuels, since the pressure on our ecosystems will be unsustainable and result in negative consequences for the environment and biodiversity (WWF, 2019).

The electrification of road transports consists of two main solutions, namely battery electricity and electric road systems (Riksdagen, 2017). In order for the electricity to be fossil-free, it must be produced from renewable energy sources, e.g. solar, wind, and hydro-power (Wee et al., 2012). The electrification of road transports requires a powerful and reliable electricity grid,

and battery electricity vehicles also require a widespread infrastructure of charging stations. Furthermore, battery electricity vehicles have a limited range, and have thus not reached the same penetration and maturity level for heavy transport as it has for passenger cars (Fossilfritt Sverige, 2021). However, battery electricity vehicles are more cost beneficial to charge than it is to drive on fossil fuels.

Lastly, hydrogen fuel can either be gas or cooled down to liquid fuel and be converted into electricity in fuel cells (Riksdagen, 2017). Hydrogen possesses very low density meaning that large volumes are required, which is a disadvantage compared to many other fuels as it makes the fuel difficult to transport and store (Dicks et al., 2018). For hydrogen to be fossil-free, it needs to be classified as green-hydrogen meaning that it must be produced from renewable energy sources through electrolysis. One of the main economic barriers is the high production costs related to green hydrogen, which are still too high to be able to compete economically with other fuels (Scita et al., 2020). To meet a potential increased demand of hydrogen, existing infrastructure, including pipelines and networks for other fuels and energy sources, e.g. natural gas, could be used (IEA, 2020). These barriers have led to hydrogen still having a low maturity level for road transport.

Table 4 presents a summary of the above-mentioned fossil-free fuel alternatives, including their respective maturity level for road transports of goods.

	Biofuels	Electrification	Hydrogen
Examples	Ethanol, biodiesel (e.g. HVO, RME), biogas	Battery electricity, electric road systems	Fuel cells
Energy source	Organic resources	Renewable electricity	Renewable electricity
Maturity level	High	Medium	Low
Main advantage	Cost efficient, viable in existing infrastructure	Cost efficient in operation	High potential for heavy vehicles, partly viable in existing infrastructure
Main barrier	Limited raw material supply	Unreliable infrastructure and limited range	Storage and distribution difficulties, high cost

Table 4. Summary of the attributes of the three main fossil-free fuel alternatives.

4.2 Presentation of GVC actors

The following empirical findings are based on the four lead firms' respective GVCs related to road transports. All responding GVC actors in this thesis and how they relate to each other are summarized in *Figure 4*. Lead firms act as transport buyers in this context, and govern the activities, processes and participants in its GVC. The other actors, namely the road carrier, truck manufacturers and energy providers are all actors that can be direct or indirect suppliers to the lead firms in relation to road transports. Based on the lead firms' GVCs in this context, road carriers act both as suppliers of transportation to the lead firms, as well as buyers of trucks from truck manufacturers and buyers of fuels from energy suppliers. Therefore, truck manufacturers and energy suppliers are direct suppliers to road carriers, and indirect suppliers to lead firms, marked with arrows in *Figure 4*. However, it is important to note that all actors are somewhat

interrelated and have relationships with each other where they can work in collaboration regarding greening of road transport, which is marked with the bold dotted line labeled inter-firm relationships covering all GVC actors in *Figure 4*.

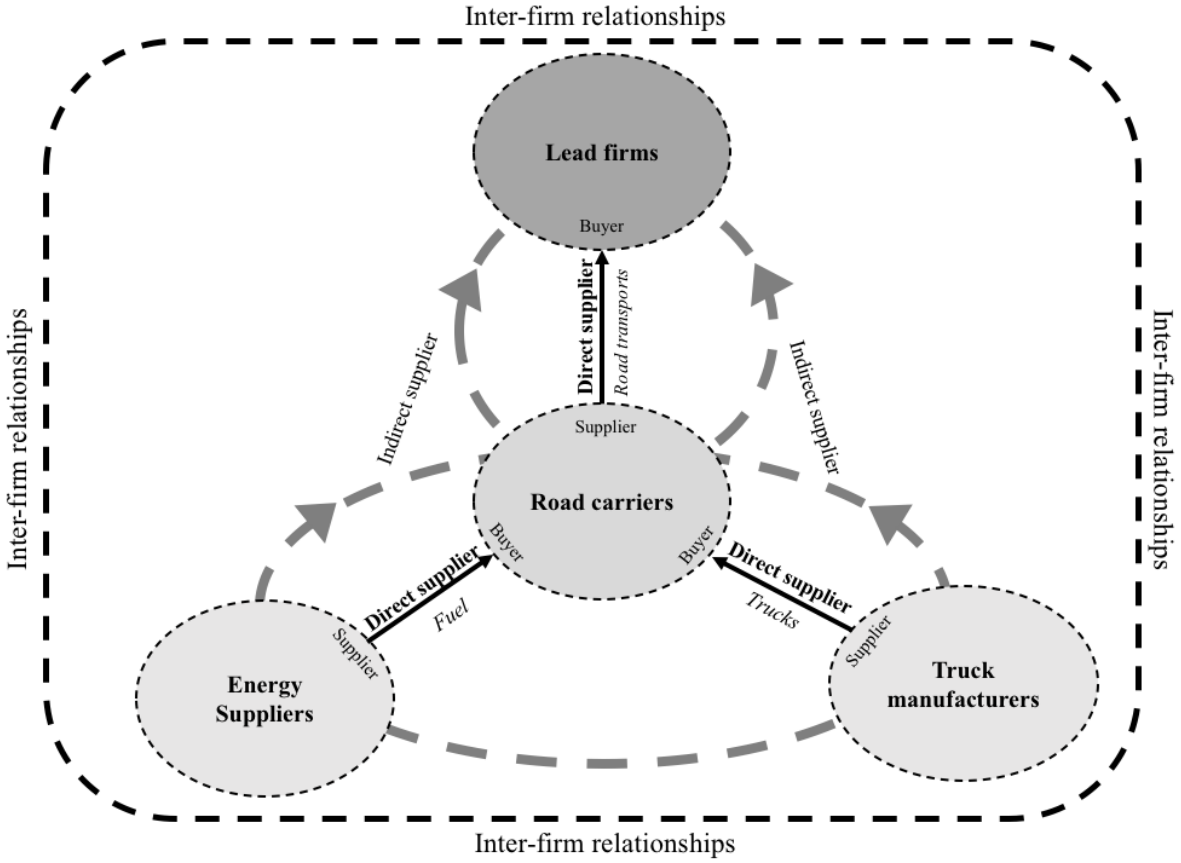

Figure 4. Presentation of the GVC actors. Self-constructed model summarizing the buyer-supplier relationships of the GVC actors related to road transports that are included in this study. The model includes both direct and indirect buyer-supplier relationships between the actors, but also shows other inter-firm relationships that may exist between any of the actors.

4.3 Lead firms

When taking a GVC perspective, lead firms have a large variety of suppliers, thus, the term "carrier" is used when referring to suppliers of transportation and the term "supplier" is used when referring to suppliers of raw materials or other inputs. In a transportation context, lead firms act as transport buyers in their respective GVCs. All empirical findings are compiled from the respective interview with the respondents from CompanyX, Lidl Sweden, SCA and Essity, if no other is cited.

4.3.1 CompanyX

CompanyX is a multinational corporate retail group that manufactures consumer products, selling its products both through its own e-commerce and physical stores. The company is present with 300+ stores in over 40 countries. The corporate group consists of two main parts, one responsible for the stores and the other managing product development, supply management etc., which is where RespondentX operates.

The interview was conducted with RespondentX, who is Sustainability Developer focusing on environmental issues within sourcing and specifically the category of heavy land transports within Scandinavia, the Baltic countries and the UK. Heavy land transport includes transportation from warehouse to store, from supplier to warehouse or from supplier to stores etc. and excludes pick-up and home deliveries which are managed by the stores.

4.3.1.1 Mapping the GVC: suppliers and transportation

CompanyX has a supplier base consisting of 1200+ suppliers operating in over 50 countries. The supplier base provides CompanyX with a variety of supplies and services, from input raw materials and in some cases processing (manufacturing, assembling etc.), to transport activities, as seen in *Figure 5*. However, many of the activities between components to distribution and B2C sales in the supply chain stages are in-house activities performed by CompanyX itself.

CompanyX has an ambition to have long-term relationships with its suppliers. When selecting new suppliers, the suppliers must meet CompanyX's internal Code of Conduct which applies for all selection of suppliers globally in the organization. The Code of Conduct is the basis for developing shared values between CompanyX and its suppliers, and includes around 100 strict requirements on both social, environmental and economic aspects which all must be achieved in order to become a supplier for CompanyX. For a producing supplier, the start-up time to become a new supplier for CompanyX is around a year.

"We require a lot from our suppliers. It's a massive effort to start working with a new supplier for CompanyX". [Authors' translation]

When working with a current supplier, CompanyX has a department with around 100 auditors that are spread globally to ensure that the Code of Conduct is followed. The auditors visit the suppliers on site to make Code of Conduct revisions. If it is found that a current supplier violates

the Code of Conduct e.g. regarding ethical or social requirements, the supply is paused. Nevertheless, if a violation occurs CompanyX does not just leave the supplier with the issue, instead CompanyX requires the supplier to find a solution for the issue and also help them to do so. In addition to meeting the Code of Conduct, CompanyX also selects suppliers based on its ambition to grow together with them. This is especially important as CompanyX has ambitious goals both regarding financial growth, but also sustainability goals.

> *"We are clear when speaking to our suppliers that if they don't reach these goals that we have set up, we're not going to reach them either and, in that case, we will not be able to continue the collaboration long-term."* [Authors' translation]

One important category of suppliers for CompanyX is road carriers. Transportation is carried out between all supply chain stages and are procured from and provided by external road carriers but controlled by CompanyX. In some cases, suppliers provide their own transport that has to be compliant with the Code of Conduct, however, up to 96-97 % of transports are controlled by CompanyX through procurement contracts with external road carriers, marked as blue in *Figure 5*. In the limited cases where suppliers provide their own transports, these must also comply with CompanyX's Code of Conduct. The management of transports within the GVC is a combination of centralization and decentralization. Forecasts of production demand are made centrally which lays the foundation for the procurement and reservation that is carried out locally. However, discussions regarding expenses linked to the transports are performed on a global central level.

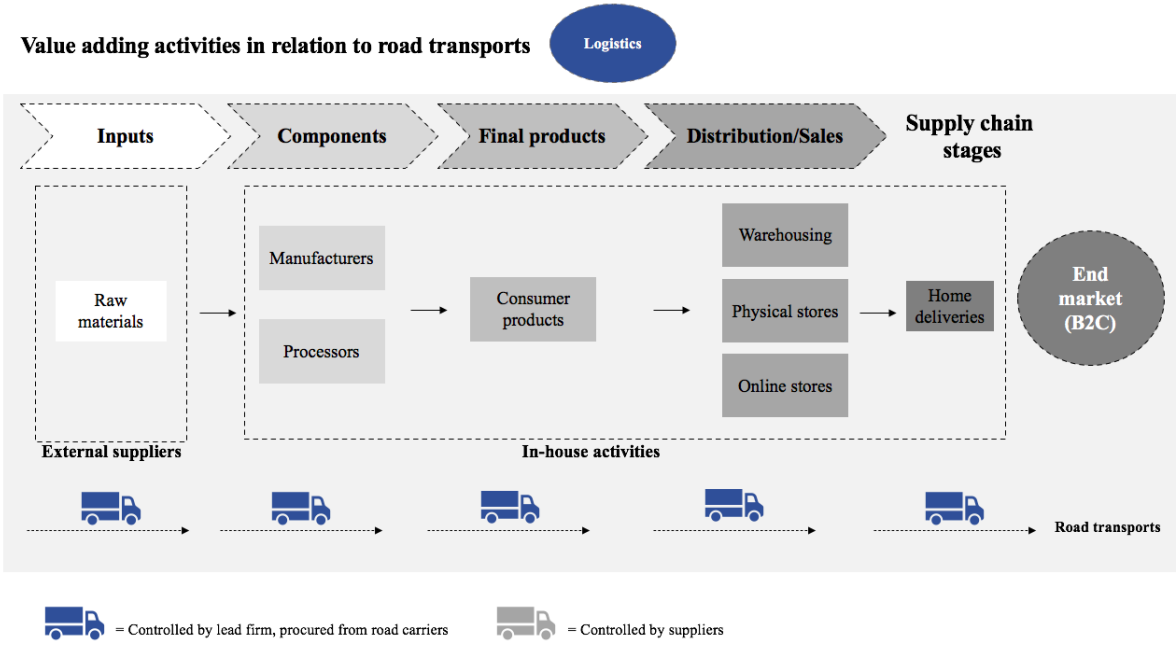

Figure 5. Mapping of CompanyX's GVC. Self-constructed figure based on Frederick's (2019) model for GVC mapping where value adding activities have been tailored to suit the road transportation context by focusing on logistics. The figure summarizes the findings from the mapping of the supply chain stages in CompanyX's GVC (inputs, components, final products, distribution/sales), and the control of the road transports between the stages (truck figures).

4.3.1.2 Greening of transports

CompanyX has formulated a sustainability strategy that applies for the entire corporate group of global companies and subunits. In addition, all different parts of the corporate group are responsible for setting specific environmental goals relevant for their operations, but no goals are allowed to be less ambitious than the overarching global sustainability strategy. Specifically, when it comes to goals linked to reduction of emissions, CompanyX has set a global goal to reduce its CO2 emissions with 15% until 2030 for the entire group. However, CompanyX are currently developing country specific goals for emission reduction since countries have different conditions and are at various stages in their sustainability development. For example, CompanyX is already fossil-free in Sweden, thus the emission level cannot be reduced to the same level as in other countries.

"Some countries, some regions, will maybe perform better numbers than others but in the end it's the total add up that counts." [Authors' translation]

The road carriers working with CompanyX have to meet the standard internal Code of Conduct, but also additional requirements that are specific for transportation. This includes environmental requirements of emission reduction programs and what kind of trucks are accepted (weight restrictions and maximum age of the vehicle) (CompanyX, 2013). These requirements apply for all road carriers regardless of their geographical location. Simply put, the road carrier must meet CompanyX's Code of Conduct or have even more ambitious goals to work with CompanyX. This is due to that CompanyX's ambitious sustainability goals permeates and lays the foundation for the entire corporate group and as CompanyX has made them official, both the internal and external pressure to succeed increases.

CompanyX ensures that the road carriers follow the set requirements by yearly follow-ups where the road carrier's results are reviewed including e.g. European emission standards on the trucks, average fuel consumption and the use of fossil-free fuels. Discussions regarding fossil-free fuels and new solutions are carried out continuously with some road carriers, where CompanyX prioritize whom to collaborate with based on the road carrier's possibility to influence the industry by e.g. larger company size and global reach. These discussions may lead up to an agreement to pilot a new solution, where it is often the road carrier that does the investments. However, CompanyX can encourage and facilitate the new solution project by committing to longer contracts with the road carrier as well as accepting a slightly higher cost for the transport.

"Of course, it needs to be an acceptable price, but the green aspect is of great importance."
[Authors' translation]

To specifically target reduction of emissions from transports, CompanyX works with a combination of ways, e.g. intermodal transport solutions, filling degree, route planning or alternative fuels. CompanyX are also involved in specific collaborations and projects with road carriers and other actors that concerns reduction of emissions from transports. CompanyX receives several requests from actors that are interested in initiating collaborations regarding transportation since CompanyX is one of the largest transmitters of goods in the world which results in CompanyX having a major impact on the industry.

The use of fossil-free fuels varies between countries where CompanyX operates. For example, in Sweden, CompanyX has completely transitioned to procure transports from external road

carriers that use fossil-free fuels. However, in other countries the usage of liquid or compressed natural gas (LNG or CNG) can be accepted, although being fossil fuels, due to lack of local alternatives and as it can serve as a gateway to a later transmission to biofuels. Nevertheless, CompanyX emphasizes that it is not an acceptable solution long-term, and the aim is always to strive for greener alternatives.

CompanyX has a specialized working group focusing on electrification and hydrogen fuel, where the group shares good examples of solutions. The main problem for CompanyX is that electric vehicles have a short range for heavy road transports, and there is a lack of well-functioning infrastructure for charging. One of the largest challenges for hydrogen fuel is also the lack of existing and functioning infrastructure, as well as the absence of hydrogen trucks. Furthermore, there is also an uncertainty regarding demand which together with the other challenges are all interrelated and forms a causality dilemma.

"It is often about who comes first, the chicken or the egg. The infrastructure does not exist as there are no truck manufacturers who produce it, as they are concerned about who will buy it. So, the question is: who should start?" [Authors' translation]

4.3.2 Lidl Sweden

Lidl is a grocery store chain originating from Germany and is a part of the multinational retail group Schwarz Group. Today, Lidl is present with 11,000 stores in around 30 countries worldwide. Lidl has an internationally defined concept that all countries should operate within, having high autonomy on how to operate within that framework. However, the level of country autonomy varies between different issues. Lidl Sweden opened its first store in 2003 which has now grown to 200+ stores spread across Sweden.

The interview was conducted with Carl Ceder who is Head of Logistics at Lidl Sweden, being responsible for all transports, warehouses and recycling on a national level. The transports cover the flow of goods between the central warehouses and the stores.

4.3.2.1 Mapping the GVC: suppliers and transportation

Lidl Sweden has three central warehouses located in Halmstad, Stockholm and Örebro, where nearly all supplies of goods go through before being distributed to the stores across the country.

As seen in *Figure 6*, there are two main supply streams for the distribution of goods through the value chain before reaching the central warehouses. The first supply stream is vertically integrated and controlled by the Schwarz Group from inputs (e.g. farmers, plants) to distribution/sales of food and groceries in stores. Thus, the Schwarz Group owns both the production facilities that produce the goods, the Lidl brand and the central warehouses. This supply stream covers Lidl's own branded goods, which stands for 85 % of the fixed product range in the stores (Lidl Sweden Sustainability Report, 2019/2020).

"So, in some cases we are 100 % integrated, so then it is the Schwarz Group from the beginning to the end." [Authors' translation]

In the second supply stream, Lidl Sweden purchases products from external suppliers who control the distribution of the goods before reaching different hubs where the loads are coordinated and re-distributed to the national central warehouses where Lidl Sweden gains full control, which can be seen in *Figure 6*. All external suppliers are required to follow a Code of Conduct formulated by the Schwarz Group, including requirements for the suppliers to ensure that their subcontractors comply with the Code of Conduct as well (Schwarz Group, 2020). Overall, Lidl Sweden aims to establish long-term relationships with all its suppliers to ensure mutual reliability between the parties (Lidl Sweden Sustainability Report, 2019/2020).

Regarding transportation, Lidl Sweden has full control over the distribution of goods from the national central warehouses to the stores, as seen in *Figure 6*, since the transports are procured at a national level. However, Lidl Sweden has an indirect impact on the international distribution from the first supply stream controlled by the Schwarz Group into the national central warehouses as well. The transports for the first supply stream are procured on an international level and the requirements often differ from the requirements set nationally by Lidl Sweden. Nevertheless, Lidl Sweden has the possibility to suggest new ideas and link different parts and transport solutions.

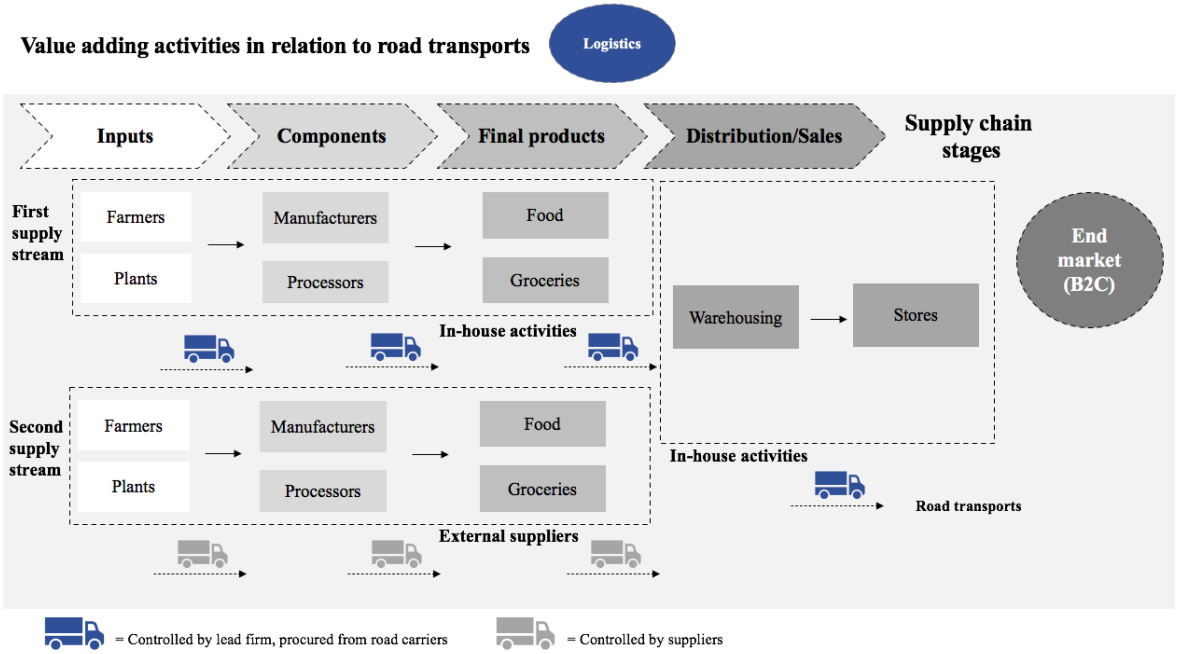

Figure 6. Mapping of Lidl Sweden's GVC. Self-constructed figure based on Frederick's (2019) model for GVC mapping where value adding activities have been tailored to suit the road transportation context by focusing on logistics. The figure summarizes the findings from the mapping of the supply chain stages in Lidl Sweden's GVC (inputs, components, final products, distribution/sales), and the control of the road transports between the stages (truck figures).

4.3.2.2 Greening of transports

The Schwarz Group has a common group-wide CSR strategy, and one part of ensuring this is by including environmental and sustainability aspects in the Code of Conduct that applies for all business partnerships with suppliers in the global organization (Schwarz Group Sustainability Report, 2018/2019). However, there might also be country specific sustainability goals for different issues as there might be market-specific differences in external institutions, where e.g. Sweden has a high public interest in environmental issues. For example, Lidl Sweden has formulated a goal to have 100% fossil-free transports to stores in 2025. Thus, when Lidl Sweden procures transports from road carriers, the general Code of Conduct must first and foremost be followed. In addition to these general requirements, Lidl Sweden formulates a detailed technical specification of the transport regarding e.g. size of truck, fuel used and sometimes even recommends different truck manufacturers that are considered to possess the right technical know-how for a specific solution when procuring transports.

Lidl Sweden performs follow-ups on the road carriers that the company is working with, where different parameters on e.g. number of driven kilometers, driven kilometers per fuel etc. are

reviewed based on centrally defined guidelines. These parameters are then converted to CO2 equivalents to ease the comparability. In addition, Lidl Sweden also performs random samples at the road carrier to ensure that the road carrier is following the technical specifications agreed.

Lidl Sweden works with reduction of emissions of its transports by two main parts. The first part relates to selection of technical solutions. This includes making an assessment of what Lidl Sweden believes are the most promising fuels and suitable fuels during that period and procure the transport based on that. The second part is linked to reducing the need for transports, which Lidl Sweden works with in a variety of ways. For example, by ensuring the highest filling degree as possible through working with optimizing packaging, but also through efficient route planning for transports.

"In one end it's of course about the technical choice. (...) The other part that has almost an even greater impact, I would say, is to minimize the need for transports." [Authors' translation]

To explore new possible technical solutions regarding fossil-free fuels, Lidl Sweden is engaged in both research projects together with universities and other public institutions, but also more hands-on projects including bringing in smaller pilot-tests of new technical vehicle solutions into the company's distribution flows. For example, in 2010 Lidl Sweden was contacted by Volvo Group who had developed a biogas hybrid truck, where the biogas could be made from waste from the warehouses. One example of a current pilot project is a collaboration between Lidl Sweden and Einride, where the two parties work with the transition towards electrification of trucks. Lidl Sweden uses Enride's software and models to explore possible opportunities to incorporate electrical solutions in parts of its distribution flow.

There is a challenge in predicting the future outlook for alternative fossil-free fuels as many solutions are still uncertain. Lidl Sweden is positive towards piloting small scale projects in its operations, however, more certainty regarding reliable infrastructure, fuel accessibility and truck technology is required if a large-scale transition to a new fossil-free fuel. Lidl Sweden is exploring a variety of fossil-free fuel options with a current focus on electricity and biogas, but as stated above, it is hard to predict the reliability of these solutions in the long term. A fuel might be considered to have a promising future; however, the situation can drastically change. For example, Lidl Sweden, amongst other Nordic companies, invested in a large-scale transition

to HVO (biodiesel) for its transports which significantly reduced its transport emissions. However, concerns were raised regarding the production of HVO since it was found to potentially include harvesting of rainforest. Based on these concerns, Lidl Sweden had to scale down the transition and continued to look into other options. Another important aspect that impacts the uncertainty regarding alternative fuels is politics, including changes in taxation on different fuels which can result in massive financial consequences for businesses.

"It does not take much to try something on a small scale, but if we were to scale up… I mean, our most important mission is to secure the supply of goods to our stores. (...) So it must be reliable." [Authors' translation]

4.3.3 SCA

SCA is a Swedish forest company based in Sundsvall, a city located in north eastern Sweden. SCA is Europe's largest private forest holdings and with the forest as a base, the company has sales activities in most parts of the world. The company consists of five main business units: Forest, Wood, Pulp, Paper, Renewable Energy, but also the supporting unit Sourcing & Logistics.

The interview was conducted with Magnus Svensson, who is the President of the Sourcing and Logistic unit at SCA. The unit is responsible for the Sourcing and Logistics for all business units (including transports) at SCA, aiming at supporting and strengthening their competitiveness and the overall performance of the logistics across SCA.

4.3.3.1 Mapping the GVC: suppliers and transportation

SCA has high control of its raw material inputs (e.g. tree matches, wood and raw timber), as seen in *Figure 7*, and is self-supporting by about 45-50% from the company's large forest holding. Every business unit controls its own value chain, from inputs, components where the raw material is processed in SCA's mills, to distribution/sales of final products (e.g. paper, pulp, tissue and timber) which are all supported by the Sourcing and Logistics unit. The Sourcing and Logistics unit sometimes coordinates procurements for various types of goods and services for all business units if synergies can be found, otherwise procurement is done separately for the business units. SCA's has a common supplier standard for all business units that is based on the company Code of Conduct, which includes e.g. business ethics and labor conditions. Although

SCA is self-supportive to a high degree in the form of raw material inputs, the company is still dependent on a large number of suppliers.

For transports, SCA owns most of its transports, e.g. self-owned cargo ships. However, road transports are procured from external road carriers, but are controlled by SCA. Procurement of transports is done centrally at sourcing, then the call-off is locally handled at the business units. All timber transports start with road transport, and then change the mode of transport depending on the distance to the recipient. For transports of finished goods, SCA's sales are mainly B2B, as seen in *Figure 7*, where the goods are distributed to customers from SCA's warehouses. The transport to the customer is most often governed by SCA, however, it may vary.

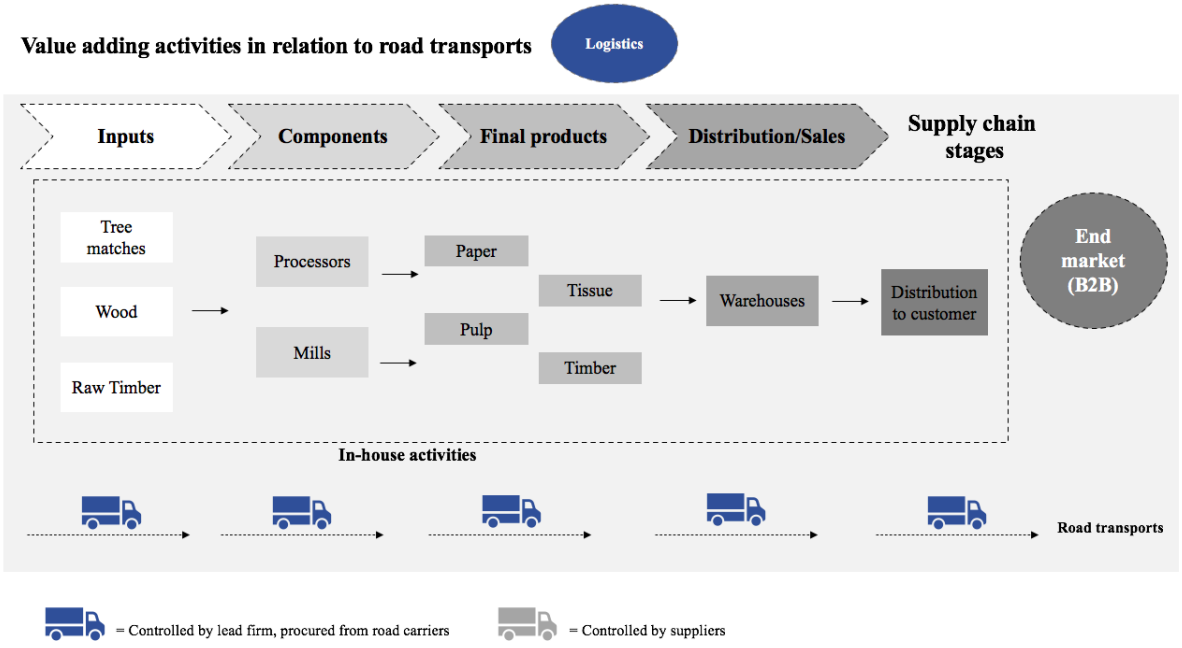

Figure 7. Mapping of SCA's GVC. Self-constructed figure based on Frederick's (2019) model for GVC mapping where value adding activities have been tailored to suit the road transportation context by focusing on logistics. The figure summarizes the findings from the mapping of the supply chain stages in SCA's GVC (inputs, components, final products, distribution/sales), and the control of the road transports between the stages (truck figures).

4.3.3.2 Greening of transports

Due to SCA's large forest holding, the company's climate benefit is significant both as the forest binds CO2, as well as its renewable products replacing fossil-based products e.g. paper instead of plastic or biofuels instead of fossil fuels (SCA Annual and Sustainability Report, 2020). However, SCA also has activities that emit fossil carbon emissions particularly from transports of products and raw materials. SCA aims to decrease the greenhouse gas emissions

by 50% in the value chain by 2030 (SCA Annual and Sustainability Report, 2020). To work with environmental improvements in the company, SCA has an employee responsible for all business units that discuss with the different business units what projects and activities to undertake and then coordinate it between the units if possible. In other words, it is carried out locally to the business units, but with a central coordination.

A large part of SCA's CO2 emissions is caused by transports and SCA uses a combination of working with fill degree, prioritizing the mode of transport with less environmental impact etc. to decrease the emissions from its transports (SCA Annual and Sustainability Report, 2020). Regarding procurement of road transports, the external road carrier must comply with SCA's Code of Conduct. In addition, SCA may set other requirements and specifications for the transport, or promote environmentally friendly initiatives e.g. eco-driving. The initiatives are then followed up by having the road carrier reporting the result to SCA. Furthermore, SCA may also require that the road carriers report what engines are used and the European emission standard of the vehicles. However, it is difficult to know what engines and European emission standards that are used in the trucks distributing SCA's goods, and thus an average is calculated.

Nevertheless, SCA's largest focus is improving the efficiency of its transports to achieve lower CO2 emission, since it is considered to have a high probability of becoming both environmentally and financially sustainable over time, i.e. "sustainable sustainability". It is a high risk to make large-scale investments in new solutions that are not certain to be environmentally and financially sustainable over time. For example, SCA started to use a type of synthetic diesel for its transports which worked well for reducing emissions, however, the initial tax reliefs and subsidies were withdrawn which resulted in the solution not being financially sustainable over time. Even though many alternative fuels are promoted as good solutions to reduce emissions, there is often uncertainty about its future.

"The question is how much companies want to invest in things that are uncertain to be sustainable sustainability, or unsustainable sustainability. But what we can say is that when we work with efficiency, resource efficiency, and lower energy consumption, we know that it has a very high probability of being sustainable long-term because it is also profitable." [Authors' translation]

SCA's business unit Renewable Energy has collaborations with energy suppliers as St1 to produce renewable energy by using tall oil (which is a by-product from SCA's wood pulp manufacturing). The collaboration means that the parties have access to the entire value chain, from raw material, refinery, distribution and sales to customers. Additionally, SCA has filed for and received an environmental permit for building its own bio-refinery for supplying biofuels. However, there are uncertainties regarding the technology, but the biggest uncertainty is the long-term political outlook and governmental policies. New political initiatives or policies can both enable, but also quickly destroy huge company investments in alternative fuels which makes it uncertain if it will become "sustainable sustainability".

"It is also very important that the policy providers set the rules so that companies have some security to invest billions in a new production of these fuels." [Authors' translation]

4.3.4 Essity

Essity is a Swedish global hygiene and health company with sales in more than 150 countries worldwide, driven by strong brands such as Tena and Tork, as well as Libero and Libresse. The company has production facilities on all continents for its business units Personal Care, Consumer Tissue and Professional Healthcare. The global supplier base consists of 30,000 suppliers.

The interview was conducted with Maria Mollberg and Sofie Kaltenbach. Maria Mollberg is director of Sustainable Sourcing, whereas Sofie Kalthenbach is Distribution Manager and responsible for all transports into and within the northern region including Sweden, Denmark, Norway, Finland and the Baltic countries. Both respondents belong to the department Global Operations and Services, meaning that they support the whole company rather than specific business units.

4.3.4.1 Mapping the GVC: suppliers and transportation

Essity is relient on a wide base of global suppliers that supplies the company with raw material inputs (e.g. pulp, nonwovens, recycled material) to its production and manufacturing of final products (e.g. Personal Care, Consumer Tissue, Professional Hygiene) as seen in *Figure 8*. Essity has a Global Supplier Standard that is based on requirements that are both Essity specific and internationally recognized standards, which all suppliers must meet. In addition to the

Global Supplier Standard, Essity also considers risk assessment since the suppliers are located all over the world. This comes with diverse risks including social, ethical and environmental depending on where the supplier is located. Based on the risk assessment, different risk mitigation actions may be required e.g. doing audits on site at the supplier.

"So, we actually do a 360 degree evaluation of the supplier, and then make an assessment." - *Mollberg* [Authors' translation]

Essity also has strategic relationships with some of its suppliers, depending on the suppliers' market, their size and the requirements from Essity's customers. Strategic relations also include transfer of information and knowledge sharing of e.g. solutions and how the supplier has solved different issues before.

"Nobody wants to reinvent the wheel; everybody tries to find solutions that can be applied for many situations." - *Kaltenbach* [Authors' translation]

Most commonly, inbound logistics of inputs of raw materials to Essity's production facilities are controlled and distributed by suppliers. When the raw materials have been refined, Essity is responsible for the distribution and transportation of the goods to and between production and storage units which is visualized in *Figure 8*. Transports are procured from external road carriers but controlled by Essity, and there is a trend towards coordination and centralization of the distribution to reach economies of scale but also to gain better control of the selection of road carriers. Furthermore, Essity's sales are mostly B2B as the company governs the distribution of goods to its customers' central warehouses or intermediators where Essity hands over the responsibility of the final distribution to end consumers.

"I would say that there is a general trend towards coordination and centralization, both to reach economies of scale but also to gain better control over requirements and selection of suppliers. When it comes to transport and distribution, we also coordinate and centralize more and more to get a better grasp and better control." - *Kaltenbach* [Authors' translation]

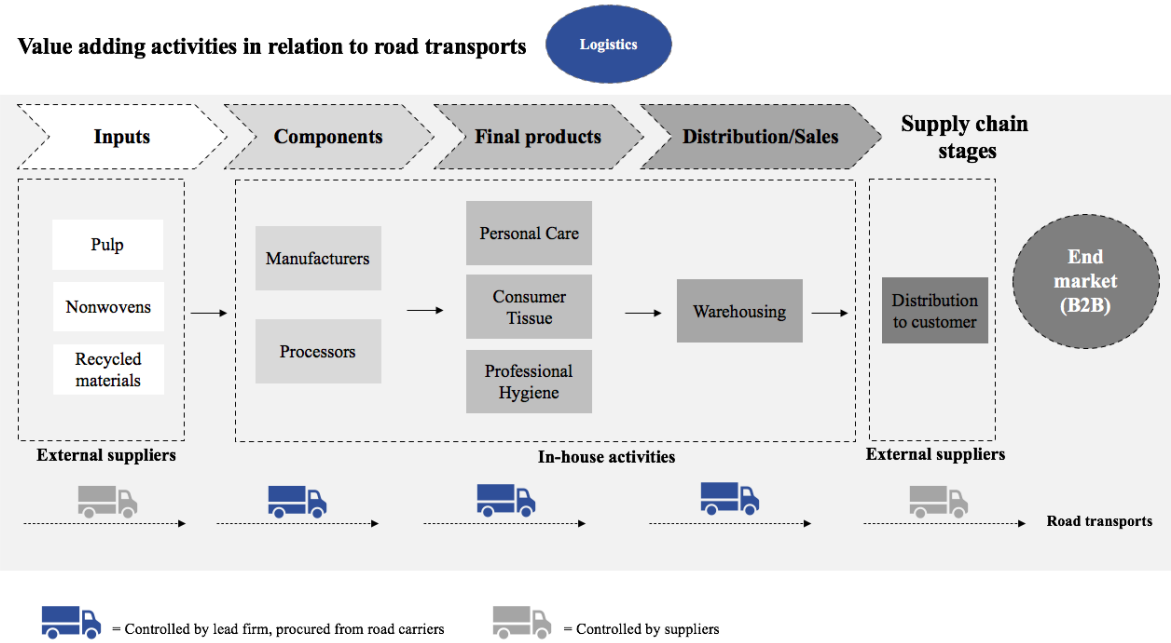

Figure 8. Mapping of Essity's GVC. Self-constructed figure based on Fredericks (2019) model for GVC mapping where value adding activities have been tailored to suit the road transportation context by focusing on logistics. The figure summarizes the findings from the mapping of the supply chain stages in Essity's GVC (inputs, components, final products, distribution/sales), and the control of the road transports between the stages (truck figures).

4.3.4.2 Greening of transports

For Essity, sustainability is a highly prioritized issue. Essity has an overall sustainability strategy that applies for the entire global organization, then specific goals are tailored for different departments. Essity has adopted the Science Based Target-initiative, which is a joint initiative established by a group of NGOs based on agreements from the climate meeting in Paris 2015. In accordance with Essity's Science Based Targets, the company has committed to reduce its CO2 emissions from transport, purchased raw materials, and waste from handling and operations with 18% until 2030 compared to 2016 (Essity Annual and Sustainability Report, 2020). To govern these goals, the company has a steering group including group management members that formulates plans on how to reach them (Essity Annual and Sustainability Report, 2020).

When procuring transports, the road carrier must meet and agree to Essity's Global Supplier Standards as a minimum. Depending on the flow, additional requirements may vary, e.g. Essity's customers might require usage of green and renewable fuels, and in turn Essity

transfers these requirements to the road carrier when procuring its transports. Other aspects that are considered are the type of vehicles and engines used to ensure that transports are compliant with European emission standards Euro5 or Euro6. For all transport flows, intermodal transport solutions are considered, as well as planning of flows to ensure high filling degree.

Contracts are used to ensure that the requirements are followed by the road carrier. Some Nordic road carriers also provide environmental reports where Essity can follow up CO2 emissions and the European emission standards used. However, in cases where there is a reason to question if the contract is followed, Essity performs audits. Nevertheless, the European supplier base of road carriers is extensive where the road carrier may use sub-contractors, which makes it complex and difficult to inspect individual transports.

> *"So even if we have a contract with a large carrier, it does not mean that they own all vehicles and have full control of their fleet. They also have an agreement with a sub-contractor, who in turn also has an agreement with someone. So it quickly becomes very complex."* - *Kaltenbach* [Authors' translation]

For Essity, the use of fossil-free fuels may vary based on geographical locations, and it depends on the availability of different fuels in the specific market. For example, HVO is largely used in Sweden and the Nordics in general compared to other markets. A challenge for a large scale use of a specific renewable fuel is to know what to invest in. Currently, Essity tries to understand and listen to what its customers are willing to invest in, to acquire guidance on what path to take. Today, the transition to fossil-free fuels often comes with an on-cost and the question is who is willing to carry the additional cost.

4.4 Road carrier

Based on the lead firms' GVCs in a transportation context, road carriers act both as suppliers of transportation to the lead firms, as well as buyers of trucks from truck manufacturers and buyers of fuels from energy suppliers. All empirical findings are compiled from the interview with the respondent from DB Schenker, if no other is cited.

4.4.1 DB Schenker

DB Schenker provides supply chain management and logistic solutions and is a global leader within the field. The company handles global operations including contract logistics, as well as air, ocean freight and land transport. DB Schenker is the largest provider of land transports in Sweden and Europe, with 430 land transportation branches across Europe.

The interview was conducted with Hanna Melander, who is Quality and Environmental Manager for the cluster Sweden, Denmark and Iceland at DB Schenker. The respondents largest focus is sustainability, including the transition to fossil-free transports.

4.4.1.1 Greening of transports

For DB Schenker, becoming fossil-free is a highly prioritized issue since the transport sector accounts for a quarter of the total global CO2 emissions, and DB Schenker is a large and important actor within the industry. In regard to road transport, where DB Schenker has its greatest disposal, the company investigates all available alternative fuels that are fossil-free. The investigation is based on a combination of risk, cost, availability and potential. Furthermore, one fossil-free fuel alternative will most probably not replace all oil-based fuels, rather, a combination of alternatives will be needed for different purposes and solutions. However, there is still great ambiguity regarding all alternatives, and one of the biggest challenges is ensuring volumes of the fossil-free fuels for DB Schenker's entire global organization. For example, the Nordic market uses a majority of the global supply of biodiesel, and thus the supply of biodiesel is not enough to cover the global demand. Hence, the global use of biodiesel is not a sustainable solution, nevertheless, it can function as an interim phase before reaching a full-scale fossil-free transition.

"We cannot really wait for all pieces to fall into place, instead we have to use all possible alternatives that are available." [Authors' translation]

Today, the different solutions for fossil-free fuels have reached various degrees of maturity. Smaller electrical vehicles have a higher degree of maturity with well-functioning solutions for charging etc., whilst for heavier trucks the degree of maturity for electricity and batteries is lower and the solution is not yet commercially viable. For heavier trucks, DB Schenker's global organization has a high interest in hydrogen as a possible alternative. Nonetheless, the use of hydrogen still involves critical obstacles to make it profitable. These obstacles include e.g.

converting the energy twice and producing large volumes of green-hydrogen, which is dependent on a secure supply of green electricity.

The shift towards fossil-free transports requires a major transition, and there is an existing demand which drives the development of solutions. However, there needs to be a secure fuel supply to an equitable price compared to fossil fuels to make the transition feasible, and the price will influence what solutions carriers and subcontractors will invest in. Also, the fossil-free fuel solution cannot be dependent on governmental subsidies or other external financing to be sustainable long-term. To work long-term, the fuel must be able to financially bear itself as well as operate on a functioning market.

"We are in the middle of something that I usually compare to the industrial revolution, and there is no question of whether there is demand - there is a demand. The concern is rather the supply. Who can deliver what we need at a price that makes it possible to make a transition?"
[Authors' translation]

4.4.1.2 Inter-firm collaborations for greening of transports

In the last ten years, transport buyers have become increasingly involved in environmental issues and it has become strategically important. This has resulted in collaborations between DB Schenker and its customers where the parties are collectively looking into new solutions and investments. DB Schenker's role is to present different alternatives and give recommendations, not only regarding price and quality, but also based on the environmental impact of different transport solutions. Close collaborations with larger customers that have customer dedicated transports might also enable joint investments between both the customer and DB Schenker (or its subcontractors) in new solutions. These joint investments often require longer contracts to assure return on the investment for the carrier by securing transport volumes.

Furthermore, the transport buyers also set various requirements, however, these might not always result in the most efficient and sustainable solution in cases where the buyer is unfamiliar with the complexity of the transport industry. For example, very specific requirements regarding pickup times could prevent DB Schenker from providing the most efficient transport solution. Therefore, the most successful transport solutions arise from close collaborations and discussions between DB Schenker and its customers about alternatives and the optimal requirements.

"Our customers set all sorts of requirements, which can also be a problem because the transport industry is quite complex and to be able to set good requirements, you need to understand the industry." [Authors' translation]

DB Schenker is involved in collaborations with not only customers, but also other actors. The increased complexity of trucks, new solutions and their required technology and supporting infrastructure require close collaborations between DB Schenker and various truck manufacturers. For example, the complexity of electric trucks involves insight in the charging infrastructure, charging times and it must be synchronized with existing transport flows. There are also collaborations including several actors to drive the transition towards fossil-free transports that work with different projects. For both biofuels and electric vehicles, there are discussion platforms where both DB Schenker, truck manufacturers, energy suppliers, government and other institutions are involved in discussing possible solutions. The initiatives can come both from governmental level, or from private actors.

4.5 Truck manufacturers

Based on the lead firms' GVCs in this context, truck manufacturers act as suppliers of trucks to road carriers. All empirical findings are compiled from the respective interview with the respondents from Volvo Trucks and Scania, if no other is cited.

4.5.1 Volvo Trucks

Volvo Trucks is part of the Volvo Group and is one of the world's largest truck manufacturers. Volvo Trucks sells and provides services for vehicles in more than 140 countries and is based in Gothenburg, Sweden.

The interview was conducted with Lars Mårtensson, who is Environmental and Innovation Director at Volvo Trucks. The respondent is part of a business function called Product Management, and responsible for the global strategic alignment of the sustainability work and the long-term development of Volvo Truck's products and services.

4.5.1.1 Greening of transports

Volvo Trucks has two main focus areas towards the transition to fossil-free transports. Firstly, reducing the energy use of trucks regardless of if it is running on fossil or fossil-free fuel, i.e. energy efficiency. Secondly, Volvo Trucks tries to find new fossil-free fuel alternatives and alternative energy carriers that could work in existing trucks but also new technology, e.g. battery electric trucks and hydrogen fuel cell trucks. Moreover, the fossil-free fuel alternatives have reached various degrees of maturity and are in different development phases. For example, biogas has been offered and available on the market for decades, whilst Volvo Trucks first started to offer electric battery trucks in 2019 and the outlook for when hydrogen fuel cell trucks could be offered is at the end of this decade. All fossil-free fuel alternatives will most probably have their own niche in the future, where e.g. electric battery trucks are more suitable for local/regional road transports, whereas fuel cell trucks are better suited for heavy long distance road transports.

For a fuel solution with low maturity or in an early development phase for trucks e.g. hydrogen fuel cell trucks, Volvo Trucks attempts to prepare the market for the new solution by sharing its development process and prospect at an early stage. Generally, for other new technologies, sharing specific information at an early stage is unusual due to confidentiality and in regard to having a technical advantage towards competitors. However, for Volvo Trucks to be able to offer trucks with new fuel solutions, the company has to inform and include buyers, governments, and energy suppliers in the process for them to be prepared when the solution is launched, and to assure reliable supply and demand.

*"For us to be able to take the steps we want in the future, we cannot come and surprise our customers, transport buyers or anyone else with 'look now all of a sudden we have a solution!'"[*Authors' translation]

4.5.1.2 Inter-firm collaborations for greening of transports

Collaboration and projects regarding new fuel solutions and technologies often involve various actors. Historically, Volvo Trucks has been working close to its large customers, however, the company has increasingly started to work with its customers' customers, i.e. the transport buyers, for new fuel solutions such as hydrogen. In general, large transport buyers have become a heavier driving force to address environmental issues and sustainability, in addition to governments and legal requirements that historically have been the major driving force.

Transport buyers have to be involved to influence current technologies and future technologies to drive development, which requires collaboration. In addition, transport buyers set requirements in connection to the procurement of the transport and engage in other ways to influence the carriers to move forward in regard to sustainability. The impact from transport buyers could vary depending on the volumes they procure from carriers, where large volumes often result in higher influence.

Strategic collaborations and/or partnerships between Volvo Trucks and its customers generally involve larger customers as their strategic agenda and conditions often align with Volvo Trucks'. These collaborations often involve openly sharing information about long-term visions and based on that develop concrete projects to jointly drive the development of new solutions. For example, Volvo Trucks has a close partnership with DHL, where DHL performs pilot-tests in its operations of new technologies and trucks produced by Volvo Trucks.

"So, it is a great benefit for us to be able to have these types of customers that we can work closely and try new technology with. And you can partly see it as a form of mutual way of driving development." [Authors' translation]

Apart from customers and transport buyers, Volvo Trucks also collaborates with energy suppliers that can supply fuel and build infrastructure as e.g. charging/fuel stations. Transport buyers, Volvo Trucks' customers and energy suppliers, amongst other actors, are sometimes involved in the same discussion or projects. This is an important aspect to create reliability for all different parts of the solution, but also to develop a common knowledge base.

Large scale projects for new fuel solutions, e.g. hydrogen, usually require the involvement of several actors that have the possibility, and are willing, to invest both time and finances. Thus, it is often the larger actors that possess the necessary resources to participate. In addition to collaborating with a broad range of actors that possess the necessary resources, Volvo Trucks often prefers to collaborate with other global companies for its new technology and trucks to attain a global presence. For example, collaborating with a global customer enables Volvo Trucks to pilot the trucks in several markets, and global energy suppliers to ensure not only local, but also global, available infrastructure for the new fuel.

"For example, for the first new hydrogen fuel trucks, if we work with a customer with a global presence, we can first test it in Sweden, the next test can be in the UK and then the US, Brazil or elsewhere in the world. The same goes for energy suppliers, for us to be able to succeed globally, it requires an infrastructure not only in Gothenburg, but it is required to be present in all markets." [Authors' translation]

4.5.2 Scania

Scania is a global provider of transport solutions, including trucks and busses. The company is based in Södertälje, Sweden, where most of the research and development (R&D) is carried out but has sales and services in about 100 countries worldwide.

The interview was conducted with Magnus Fröberg, who is Technical Manager Fuels at the Engine Development department at Scania. The respondent works with technical issues, sustainability issues and research projects in regard to R&D and fuels.

4.5.2.1 Greening of transports

Scania focuses on battery electric vehicles as a main solution for fossil-free fuels. Alongside with battery electric vehicles, electric road systems can also be a possible solution in different markets. A large reason for Scania's focus on battery electric trucks is the development of the cost structure. There are a number of industries and fields working with the development of battery electricity for making them more powerful, smaller, lighter, improving charging times etc., which also has a great effect on decreasing the cost of the technology. For example, battery electricity has gained a strong position in the passenger cars industry and thus, the development of battery electricity as a whole continues regardless of the truck manufacturers own R&D.

Scania has also worked with biofuels for many years, including both biodiesel and biogas. Biofuels are fossil-free and have been promoted as sustainable alternatives in regard to emissions compared to fossil-fuels. However, limited global access to raw materials needed for the production of biofuels does not make it globally viable. In addition, questions concerning the calculation of the actual environmental impact of the fuel have been raised and Scania is therefore working to develop a standardized calculation method of the environmental impact.

"Biodiesel is good, it's fossil-free, but how good is it really? It all depends on how you calculate, and lately we have worked hard to develop standardized ways to calculate." [Authors' translation]

The future outlook for hydrogen fuel cell trucks is a lot more uncertain, since it has not achieved the same penetration across different sectors. Thus, the development timeline for hydrogen fuel to reach cost parity compared to other fuels is longer and more uncertain.

4.5.2.2 Inter-firm collaborations for greening of transports

Scania has discussions and collaborations with both customers (road carriers) but also its customers' customers (transport buyers), including broad discussions about future outlooks and also more specific projects. For example, Scania has a collaboration with the Norwegian grocery wholesaler ASKO. The project was initiated by ASKO that requested Scania to develop a new hydrogen fuel cell truck, which was not available at the market at that time. In these collaborations, the purpose is not to develop a series of products to sell on the market, rather, these collaborations are development projects.

"ASKO was interested to start a collaboration with a manufacturer to make fuel cell vehicles, long before it was available on the market, they were very early." [Authors' translation]

The projects and collaborations are in some cases initiated by Scania, in other cases initiated together with other actors or initiated by an external actor, e.g. road carriers, transport buyers, governments, energy suppliers etc. For Scania to enter a project or collaboration for new technologies, it is important that the solution is somewhat globally applicable. For example, if a Scandinavian energy supplier wants to initiate a collaboration with Scania for a new engine for a specific green fuel, it will most likely require more than a small and local demand for Scania to engage in the project. Hence, it often requires an interest and demand for the new engine and the green fuel in larger parts of the world for Scania to enter the project.

"We can't spread out our investments, we can't prioritize all projects that sound good. We have to focus on what is the most important thing for us." [Authors' translation]

4.6 Energy suppliers

Based on the lead firms' GVCs in this context, energy suppliers act as suppliers of fuels to road carriers. All empirical findings are compiled from the respective interview with the respondents from Preem and Econ, if no other is cited.

4.6.1 Preem

Preem is the largest fuel company in Sweden with its 520 gas stations. The company is operating in Sweden and Norway and procures raw material from all over the world. Preem has two refineries, one in Gothenburg and another in Lysekil.

The interview was conducted with Peter Abrahamsson, who is part of Preem's Executive Management Group as Director of Sustainable Development. The Sustainable Development function has various responsibilities, including the development of a sustainable society, how to adapt Preem's product offering based on future requirements and the need to become fossil-free.

4.6.1.1 Greening of fuels

Preem has already established production equipment and infrastructure for liquid fuels that the company has invested a large number of financial resources in, which is Preem's largest asset. Thus, Preem aims to adapt its current assets and infrastructure to make them more suitable for fossil-free fuel alternatives. Nevertheless, charging stations for battery electric vehicles is also an important aspect that Preem aims to develop in the future. The future use and spread of the different fossil-free fuels depends on the technological development of different solutions. For example, the battery electric technology for vehicles is currently developing rapidly and has a widespread for lighter vehicles. However, the technology's future usage in heavier transports depends on the development stage of the battery capacity, and if the development is not rapid enough, hydrogen fuel cells might function as a viable alternative.

"Personally, I am convinced that battery development will outcompete most other alternatives. However, there will be areas where batteries are not enough, where they are unsuitable for various reasons. In these situations, fuel cells can be used, but so can combustion engines with renewable fuels." [Authors' translation]

4.6.1.2 Inter-firm collaborations for greening of fuels

Preem is involved in various collaborations and projects addressing fossil-free fuel solutions. However, the company is not involved in the technological development of vehicles. Instead, Preem focuses on making the liquid fuels more sustainable by e.g. initiatives in collaboration with Swedish forestry companies where the parties investigate and produce possible sustainable raw materials which Preem can process in its refineries. In these projects it is common interests that create initiatives, and both parties invest to develop raw materials. Nevertheless, Preem itself invests to be able to process the raw materials in its refineries and potential redevelopments of the refineries.

4.6.2 Econ

Econ is a provider of fossil free transport solutions by providing 100% fossil-free liquid biogas and hydrogen fuel for the commercial vehicle market, based in Gothenburg, Sweden. Econ was founded in 2019 and is a project developer, offering a complete solution of biogas or hydrogen fuel supply for e.g. heavy vehicles.

The interview was conducted with Morgan Larsson, who is Founder and CEO of Econ. The respondent is involved in most parts concerning the business operation, as the company is still in a very expansive phase.

4.6.2.1 Greening of fuels

Econ's core business is to provide 100% fossil-free fuels, which means that the company only provides green fuels. Econ is a project developer offering complete solutions that includes permissions from authorities, financing, contracts with suppliers and customers, gas plant construction and operation, as well as providing refueling stations to its customers. Each project is also a company that Econ designs and develops on behalf of a specific customer, which can be both companies operating in the heavy industry or the transport sector. The developed company for the project is then sold to an infrastructure fund that invests for returns. To finance the construction of a new gas-plant for a project that supplies green fuel, Econ applies for subsidies, both from the Swedish government and the EU. Nevertheless, an application is both time consuming and capital intensive without any guarantees for funding.

Econ has ongoing biogas projects for customers, whilst hydrogen projects are still in an early development phase. Today, the overall demand for biogas is however still modest compared to natural gas and diesel alternatives. Even though the price for biogas can be lower than the price of diesel, the use of biogas requires a transition that entails investments. In Europe, there is a transition from fossil diesel to natural gas, which has made the transportations greener but not fossil-free. The next step for even greener transportation, especially for heavy vehicles, could be a transition to biogas. However, there are limits regarding the supply of biogas which could hinder a large up-scale, and also increase the price of the fuel.

"I think the demand for biogas will grow, because it is one of few options for heavy transports that go longer distances (...) Europe is going from real dirty diesel to natural gas which is much better, but if you look at it over time, there will also be an interest for biogas. Unfortunately, biogas is a bit of a scarce commodity, which means that the price will go up and it will affect the market as well. But to counteract this, you can use other raw materials to produce gas and with that, the market will increase and the price per unit will fall."
[Authors' translation]

For hydrogen, there is a lower maturity level than for biogas where hydrogen is widely discussed but there are still very few users within the transportation sector. One of the main reasons for the limited use of hydrogen is the price of production of green hydrogen, which is still high compared to other fuel alternatives. There is a potential for a large-scale supply of hydrogen, however, it depends on how much the customer is willing to pay.

4.6.2.2 Inter-firm collaborations for greening of fuels

All Econ's projects involve other actors, e.g. producers (electricity companies, wind power companies, suppliers of organic resources etc.) and customers (road carriers, transport buyers etc.) depending on the specific project. When initiating new projects, it is Econ that addresses potential customers. One of the challenges of being in the early phase is to get in contact with the right people at the right place.

"We are a start-up company and it's a challenge to be seen in this industry, unfortunately, and it's a challenge for small companies that have good ideas." [Authors' translation]

An important part of Econ's projects is risk mitigation for the involved parties. This is done through long contracts and the external financing from the Swedish government and the EU. Econ reduces the risk in the project by offering a fixed price of the fuel. The projects often require external financing as they are very cost intensive. However, the projects are only initialized when it involves a large amount of gas, thus extensive projects, as it is required for the infrastructure funds to invest.

"The reason why we do this is that it is quite expensive infrastructure projects, these projects can cost some hundreds of millions SEK… You need to have some money in your pocket to do it yourself, therefore we do these kinds of projects and start the company". [Authors' translation]

4.7 Summary of empirical findings

A summary of the empirical findings of all GVC actors is found in *Table 5-7* below. *Table 5* includes all lead firms, *Table 6* includes the road carrier and truck manufacturers, and *Table 7* includes energy suppliers.

Lead firms Findings	**CompanyX**	**Lidl Sweden**	**SCA**	**Essity**
Main end market	B2C	B2C	B2B	B2B
Ensuring supplier/carrier behavior	Code of Conduct, contracts, regular audits, yearly follow-ups, long-term relationships	Code of Conduct, contracts, technical specifications, follow-ups, random samples, long-term relationships	Code of Conduct, contract, follow-ups	Global Supplier Standard, contracts, audits when suspecting violation of contracts, risk assessments, occasional follow-ups
Targeting CO2 emissions from transports	Intermodal transport solutions, filling degree, route planning, alternative fuels, European emission standards	Selection of technical solutions, reducing the need for transports (e.g. filling degree, route planning)	Filling degree, prioritizing mode of transports with less environmental impact, transports efficiency, eco-driving, European emission standards	Filling degree, intermodal transports, European emission standards
Working with fossil-free fuels	Varies between countries, working group for electrification and hydrogen, pilot projects for new fuel solutions	Exploring options; focus on electricity and biogas, assessments for most promising fuels, pilot projects for new fuel solutions	Business unit for renewable energy	Investigating customer demands
Interfirm collaboration for fossil-free fuels	Discussion and collaboration with some (large) carriers, specific projects with carriers and other actors	Collaboration with truck manufacturers, projects with universities and other institutions	Collaboration with energy suppliers where SCA provides input materials	Science based targets
Challenges for transitioning to fossil-free fuels	Transition on global-scale, causality dilemma for new fuel solutions	Large scale transition, uncertain future outlook of alternatives	High uncertainty and risk	Who should carry the cost, deciding what to invest in

Table 5. Summary of empirical findings for lead firms.

Suppliers Findings	**DB Schenker**	**Volvo Trucks**	**Scania**
Supplier relation to lead firms	*Direct supplier*	*Indirect supplier*	*Indirect supplier*
Actor	Road carrier	Truck manufacturer	Truck manufacturer
Working with fossil-free fuels	Working with a combination of fuel alternatives, investigating different options	Investigates fossil-free fuel alternatives that could work in existing trucks but also new technology, e.g. battery electricity and hydrogen, believes that fuels will have their own niche	Focuses mainly on battery electric vehicles, investigates electric road systems
Interfirm collaboration for fossil-free fuels	Collaboration with large customers where the parties are collectively looking into new solutions and investments, cross-sectoral partnerships for discussing possible solution, collaboration with truck manufacturers to gain technological insights	Increased collaboration with transport buyers, strategic collaboration with carriers, collaborations with energy suppliers for securing infrastructure, joint discussions with several actors to create a common knowledge base	Collaboration with transport buyers, e.g. developing hydrogen fuel cell trucks for ASKO, other collaborations with e.g. carriers, transport buyers, governments, energy suppliers etc.
Challenges for fossil-free fuel alternatives	Ensuring volumes of alternative fuels to make a full-scale transition to an equitable price	Preparing market for new solutions to assure reliable supply and demand	For biofuels - limited raw material access, for hydrogen - still an uncertain solution, fuel alternatives being globally applicable

Table 6. Summary of empirical findings for the road carrier and truck manufacturers.

Suppliers Findings	**Preem**	**Econ**
Supplier relation to lead firms	*Indirect supplier*	*Indirect supplier*
Actor	Energy providers	Energy providers
Working with fossil-free fuels	Aims to adapt its current assets and infrastructure to make them more suitable for fossil-free fuel alternatives	Providing fossil-free hydrogen and biogas
Interfirm collaboration for fossil-free fuels	Collaborating with Swedish forestry companies for raw material inputs for liquid fuels	Collaborates with several actors in each project e.g. producers and customers
Challenges for fossil-free fuel alternatives	X	Modest demand for biogas, few users of hydrogen, high investments for transitioning for Econ's customers, current price of hydrogen, get in contact with the right people at the right companies

Table 7. Summary of empirical findings for energy suppliers.

5. Analysis

The fifth chapter presents an analysis following the conceptual framework in relation to the empirical findings. The chapter firstly provides an empirical motivation for the private regulation approach. Secondly, an analysis of the lead firms' governance of road transport is conducted followed by a discussion of sustainability governance in relation to general governance structures. Thirdly, environmental upgrading and the underlying driver for suppliers is discussed. Fourthly, an elaboration of the role of inter-firm collaborations for greening and reaching collaborative advantage is carried out. Lastly, the conceptual framework is revised based on the empirical findings to increase its applicability.

5.1 Regulation of greening in GVCs

One part of Frederick's (2019) GVC mapping model is the supporting environment including external institutional actors as governments that creates legal parameters, influencing the participating actors in the other parts of the GVC. This is what could be referred to as state regulation. However, as already stated, private regulation initiatives created by GVC actors are more important in complex and dispersed GVCs, as state regulations can be argued to have limited impact (Wahl & Bull, 2014). In the empirical findings, some respondents strengthen this argument and describe that politics have a somewhat limited impact on greening of GVCs due to that it may contribute to uncertainties regarding the future outlook for fossil-free fuels. For example, SCA describes that new political initiatives can both enable e.g. investments in alternative fuels, but also quickly destroy them by e.g. removing subsidies. This is also described by Lidl Sweden, who emphasizes how changes in taxation on different fuels can result in massive financial losses for businesses. Furthermore, DB Schenker highlights the importance of a fossil-free fuel solution that can financially bear itself to work long-term, and that is not dependent on governmental subsidies. Nevertheless, Econ describes that state regulators can help to finance projects for green fuel plants, however, without any guarantees for funding which creates an uncertainty. Thus, although state regulations might support a transition to a fossil-free fuel short term, possible shifts and uncertainties in state regulations creates risks and insecurities to invest fully in a new solution. This could also result in lead firms being willing to make small-scale investments on fossil-free fuels for specific markets, rather than perform a major global-scale transition. As highlighted by Lidl Sweden, doing small-scale investments does not require much, but for large-scale transitions there are still too many uncertainties.

As mentioned above, another important aspect that constrains the impacts of state regulations in GVCs is the geographical dispersion of the chains, as state regulations often apply on a national level. As described by CompanyX, Lidl Sweden and Essity, there can be large variations and market-specific differences in the use of fossil-free fuels and external institutions between countries where the lead firms operate. For example, CompanyX has completely transitioned to fossil-free transports in Sweden but emphasizes that in other markets the company accepts fossil natural gas as fuel due to the lack of other local alternatives. This indicates that the state regulations could vary between countries, and thus, the national features of state regulations limit their impact on greening the entire GVCs.

In summary, the empirical findings support that state regulations have a limited impact on greening of GVCs in terms of fossil-free fuels, both due to future uncertainties regarding state policies on a national level, and that state regulations often apply on a national level limiting their global impact. Therefore, private regulation created and governed by GVC actors is an important aspect for analyzing greening of GVCs, which will be carried out below taking both a top-down and a bottom-up perspective.

5.2 Governance and governance structures of road transports

Governance is related to the power of actors to influence and control the activities in GVCs (Gereffi, 2011). Governance of GVCs often refers to lead firms (Khattak & Pinto, 2018) that can act as either producers or buyers in their GVCs (Gereffi, 2011). Considering that the lead firms studied in this report act as transport buyers in their GVCs, they have the power to govern and control the transports through procurement and contracts with external road carriers. Hence, all lead firms in this study operate in buyer-driven chains in relation to road transport and their road carriers. This would imply that the road carriers have large upgrading opportunities, as Gereffi (1994) argues that suppliers in buyer-driven chains often hold important competencies whilst the buyer (i.e. lead firm) focuses on its core business.

To explain how lead firms govern their GVCs, Gereffi (2011) outlines five different governance structures. It is evident from the empirical findings that the governance structures of the lead firms vary in relation to different road carriers within the chain. The GVC mapping of the lead firms illustrates how road transports between the supply chain stages are outsourced to external

road carriers, which are then controlled by either the lead firm or a supplier. However, it is also evident from the GVC mapping that the majority of road transports between the supply chain stages are controlled by the lead firms. These findings align with Gereffi's (2011) description of network style governance (being modular, relational and captive governance), as the lead firms use various means of coordination to gain power without any direct ownership of the road transport fleet.

5.2.1 Captive governance structure

To govern their road transports, all four lead firms apply a Code of Conduct that the road carriers have to comply with in order for the lead firm to work with the carrier. This way of controlling the road carriers is in line with what Gereffi (2011) labels as captive governance, where the lead firm holds high power and controls the activities of the carrier through e.g. contracts and audits. The use of contracts, including the Code of Conduct, to gain high control and coordination of the road carriers can be useful as all the lead firms transport large volumes in their chains where it is hard to control individual transports. CompanyX describes how they are dependent on the road carriers to provide them with green road transports that comply with their internal company sustainability goals to be able to reach these goals. This is because CompanyX relies on external carriers for their road transports, which causes a lot of their total CO2 emissions. The same situation is applicable for all four lead firms and could further explain their use of captive governance in relation to road carriers. As emphasized by Gereffi (2011) captive governance is also characterized by power asymmetry between the lead firm and the supplier. This is especially evident in this study as all lead firms are powerful MNEs with heavy volumes of goods, financially motivating road carriers to comply with the lead firms' Code of Conduct as the carriers are generally eager to work and keep large lead firms in their customer base, regardless of the carrier's size.

Another aspect of captive governance is to perform audits (Gereffi, 2011), which is used to various degrees by the investigated lead firms. For example, CompanyX has a department that performs audits globally at its current suppliers' sites, including road carriers, to ensure that the Code of Conduct is followed. Moreover, Lidl Sweden does not perform audits of its road carriers on a regular basis, however, the company performs follow-ups and random samples at the road carriers' sites. Similarly, SCA does not perform any audits, instead the company makes follow-ups where SCA relies on its road carriers to report e.g. what engines are used and the European emission standard of their trucks to calculate an average, due to the difficulty to

investigate individual transports. Essity, however, performs audits in cases where there is a reason to question if the contract is followed. In addition, some Nordic road carriers also provide Essity with reports of CO2 emissions and the European emission standards used. Nevertheless, Essity also highlights the difficulty with inspecting individual transports, as the transport industry is complex where the carrier may use sub-contractors and thus does not necessarily have full control of their fleet, which is a similar issue as described by SCA. These findings support the logic of the lead firms adopting captive governance in terms of contracts with road carriers, as it is proven hard to monitor individual activities that are performed by external road carriers using second-tier suppliers, or even third-tier suppliers.

5.2.1.1 Limitations of captive governance structure

As argued for above, the lead firms act as transport buyers and thus operate in buyer-driven chains, and in accordance with Gereffi (1994), this implies that the road carriers hold important competencies. This entails that the road carriers can contribute significantly to greening of transports, also due to that the lead firms are relying on road carriers for their transports. However, when lead firms adopt captive governance by setting various requirements that the road carriers have to comply with, it can simultaneously limit carriers from providing the most sustainable transport solution possible. This is exemplified by the road carrier DB Schenker who describe that in the case where lead firms are not familiar with the transport industry, the lead firm might set requirements that are too specific, and thus inhibit DB Schenker from providing the optimal transport solution in terms of both efficiency and environmental sustainability. According to Wolf and Seuring (2010), the requirements in regard to environmental performance can be set too low compared to what the carriers are able to perform. Hence, this contradicts Gereffi's (1994) argument that suppliers in buyer-driven chains have large upgrading opportunities, as the empirical findings show that captive governance might hinder the road carriers to utilize their full capabilities related to greening.

5.2.2 Relational governance structure

CompanyX however also describes how the company works more closely with some road carriers and continuously have discussions about new solutions, where CompanyX prioritizes large carriers with global presence and a possibility to influence the industry. This evens out the power asymmetry, creates mutual dependency and a power balance, and thus this type of governance structure is in accordance with Gereffi's (2011) definition of relational

governance. Gereffi (2011) describes that relational governance includes complex information transactions and long-term relationships that are time consuming to build, and thus it is costly to switch partners. In line with this, CompanyX describes how it is a massive effort to start working with a new supplier as the company has an ambition to have long-term relationships with all its suppliers, and these are time consuming to build.

5.3 Sustainability governance

It has been found that all the lead firms work in various ways to specifically target reduction of CO2 emissions from transports. All the lead firms work with transport efficiency, i.e. streamlining the transport solutions that already exist to reduce CO2 emissions from transports. However, it is only CompanyX and Lidl Sweden that explicitly mention working with alternative fossil-free fuels as a means to target CO2 emissions from road transports. The logic behind this could be explained by the fact that transport efficiency has lower risk and less uncertainties long-term for the lead firms and imply cost savings. On the other hand, transitioning to fossil-free fuels often involves many uncertainties and large investments. SCA explains that transport efficiency is considered to have a high probability of becoming both environmentally and financially sustainable over time, whereas fossil-free fuels are associated with higher risks and uncertainties. Nevertheless, this indeed implies that the lead firms influence and control various activities to foster greening of GVCs through reducing CO2 emission, referred to by Bush et al. (2015) as sustainability governance which is also further evaluated below.

5.3.1 Mentor-driven and standard-driven sustainability governance

Similarly, to Gereffi's (2011) captive and relational GVC governance, De Marchi et al. (2013a) present two approaches on how a lead firm can govern specifically the greening of GVCs, namely standard-driven and mentor-driven greening. Standard-driven greening is described as lead firms establishing environmental standards for new and existing suppliers (De Marchi et al., 2013a), which is much in line with the discussions above about the lead firms that adopt a captive governance structure in accordance with Gereffi (2011). In the same way, mentor-driven greening where lead firms have personal interactions sharing skills and knowledge with their suppliers (De Marchi et al., 2013a) is instead in line with a relational governance structure as described by Gereffi (2011). Thus, one can assume that similar conclusions can be drawn for

mentor-driven and standard-driven greening as for captive and relational governance structure in relation to how lead firms facilitate the utilization of their road carriers' greening capabilities.

As aforementioned, the empirical findings indicate that lead firms adopting captive governance/standard-driven greening lock the road carrier to the lead firms' requirements, resulting in that the carrier is not able to make use of its full greening capabilities to environmentally upgrade. However, heavy volumes can make the standard-driven greening more convenient as the lead firms are dependent on many carriers that have to follow their sustainability requirements. In contrast, relational governance/mentor-driven greening requires the lead firms to invest more time and resources to the relationship compared to established standards (Gereffi, 2011). Nevertheless, lead firms adopting mentor-driven greening can help to make use of their road carriers' full greening capabilities. DB Schenker strengthens this argument by emphasizing that the most successful transport solutions derive from close collaborations and discussions between DB Schenker and transport buyers (e.g. lead firms) about the optimal requirements. Further in line with these reasonings, De Marchi et al. (2013a) stress that cooperation has a positive impact on the development of green offerings and overcoming heavy transaction costs linked to it. This could potentially compensate for, and even out the time consuming and resource intensive nature of relational governance/mentor-driven greening.

5.3.2 Internal perspective of sustainability governance

Based on the empirical findings, the investigated lead firms mainly adopt an internal perspective of sustainability governance of their GVCs. According to Bush et al. (2015), the internal perspective refers to governing sustainability *in* and *of* chains. Governing sustainability *in* chains refers to when lead firms effectively control the environmental impact of the supplier by receiving performance indicators from the supplier (Bush et al., 2015). As already explained above, all four lead firms perform audits and/or follow-ups on their road carriers, which are all examples of how sustainability is governed *in* chains with the aim to accomplish greening of their road transports.

However, CompanyX and Lidl Sweden can also be argued to adopt sustainability governance *of* chains for greening of road transports, which Bush et al., (2015) describe as lead firms setting standards for their suppliers to drive change among the actors, but also transferring necessary knowledge and technology to improve the sustainability performance of their suppliers.

CompanyX has an internal group working with specifically electrification and hydrogen that shares good examples of solutions and continuously discusses new solutions with some of their road carriers, which may lead up to pilots of new green solutions. Similarly, Lidl Sweden occasionally shares knowledge and information to road carriers by recommending them to work with specific truck manufacturers that possess technical know-how for a specific fossil-free solution. These are both examples where the lead firms aim to improve the sustainability performance of the road carriers' processes by sharing their knowledge, i.e. enhancing environmental upgrading for road carriers. Additionally, information sharing in inter-firm relationships is stressed by Wolf and Seuring (2010) as an important factor to increase suppliers' environmental performance. This could further indicate that sustainability governance *of* chains facilitates the environmental upgrading of road carriers, by improving the inter-firm relationship between the lead firm and the road carrier. A possible explanation that CompanyX and Lidl Sweden adopt sustainability governance *of* chains is that both companies operate B2C in contrast to the other studied lead firms, which according to Poulsen et al. (2016) increase the external pressure on greening due to higher reputational risk. Thus, CompanyX and Lidl Sweden that are consumer-facing might have more incentives to achieve their CO2 reduction goals by enhancing environmental upgrading of their road carriers, as they face stronger criticism from consumers if they fail.

5.3.3 External perspective of sustainability governance

In addition to having an internal perspective on sustainability governance, the empirical findings also reveal that some lead firms also adopt an external perspective to lower CO2 emissions from road transport and work with fossil-free fuels. Bush et al. (2015) refers to the external perspective as sustainability governance *through* chains, which includes a broader scope of interactions with both internal and external actors, to influence greening of the GVC but also beyond the chain. For example, Lidl Sweden is involved in research projects with external actors such as universities and other public institutions to explore new possible technical solutions regarding alternative fuels. These partnerships also include external actors to the GVC could influence greening of both Lidl Sweden's GVC, but also beyond it by contributing to the overall development and research of alternative fuels. In addition, Ponte (2019) describes that cross-sector partnerships can function as a steering mechanism to set voluntary rules for sustainability for the actors involved. An example of such voluntary rules that could drive change beyond the GVC of the focal lead firm are Science Based Targets that Essity adopts to lower its emission levels. This can drive sustainability governance *through*

chains as the actors involved influence each other to lower their emission levels by reaching their targets (Ponte, 2019), but also inspires others to adopt the same initiative.

It is evident from the empirical findings that sustainability governance *through* chains to specifically transition to fossil-free fuels is a challenge, much due to the unpredictable future outlook of the various fuel alternatives. All four lead firms express an uncertainty regarding what fuels to invest in and transition to, and this issue becomes even more complex as sustainability governance *through* chains, according to Bush et al. (2015), includes a broader scope of actors interacting. Thus, it is a challenge to reach some degree of consensus among the different actors regarding the future of different alternative fuels, again due to the many uncertainties of the fuels. As described by Essity, the transition to renewable fuels generally comes with an on-cost that someone must be willing to carry. In addition, CompanyX points out a causality dilemma meaning that many parts must be in place to have a complete functioning fuel solution. Hence, a variety of actors must reach consensus and be willing to carry the cost.

5.4 Environmental upgrading

Environmental upgrading refers to the process where economic actors in a GVC work to avoid or reduce their environmental damage (De Marchi et al., 2013b). As described by Havice and Campling (2017) and De Marchi et al. (2013b), environmental upgrading takes a bottom-up perspective, which in this study refers to environmental upgrading of direct suppliers (i.e. road carriers) and indirect suppliers (i.e. truck manufacturers and energy providers) to the lead firms.

5.4.1 Drivers for environmental upgrading

The drivers for the direct suppliers and indirect suppliers to environmentally upgrade can be both reactive (e.g. customer demands or regulation response drives upgrading) and/or proactive (e.g. greening strategies, energy optimizations, brand repositioning and new product/service development drives upgrading) (Poulsen et al., 2018). When working proactively, suppliers have their own autonomy to create sustainable strategies (De Marchi & Di Maria, 2019), where their own strategic intent, capabilities and competencies, along with support from lead firms, are crucial factors (Khattak et al., 2015).

DB Schenker describes how fossil-free transportation is a highly prioritized issue and the company investigates all available alternative fuels that are fossil-free. These are characteristics of internal drivers, which according to De Marchi & Di Maria (2019) includes more proactive actions. On the other hand, DB Schenker explains that there is an existing demand for fossil-free transports which drives the development of new solutions, and in the end the price will determine what solutions carriers will invest in. These are characteristics of external drivers in accordance with De Marchi & Di Maria (2019), which includes more reactive actions as a result of market demands and stakeholder requests.

Environmental upgrading can further be described as an innovation process that develops and utilizes new technical knowledge (De Marchi & Di Maria, 2019). Both truck manufacturers included in this study are working proactively to innovate and develop new solutions for fossil-free fuels to environmentally upgrade, however with different focuses. Scania focuses mostly on developing battery electricity, whereas Volvo Trucks invests in both battery electric solutions and hydrogen. Furthermore, Volvo Trucks prepares the market by sharing parts of the development process for new fuel solutions such as hydrogen which can be seen as proactive actions that are internally driven. Scania has a somewhat more reserved and reactive approach to the development of hydrogen solutions, as the company prioritizes a proactive development of battery electric solutions. Scania describes that the development of battery electric solutions is driven across several industries, and that the development of battery electricity as a whole continues regardless of the truck manufacturers own R&D. In other words, this can be underlying external drivers that explains that Scania is also reactive to the general cross-sectoral development.

The approach and drivers for environmentally upgrading by transitioning to fossil-free fuels significantly differs between the energy suppliers. Preem aims to adapt its current assets for fossil-free fuel alternatives and believes that the future outlook for different fossil-free fuel alternatives depends on technological development. Thus, Preem will adapt to the development and therefore takes a reactive approach driven by external factors. Preem attempts to develop an extended charging infrastructure for electric vehicles, however, it is still triggered by external drivers such as customer demand. Econ, on the other hand, has a very proactive approach to fossil-free fuels and the overall company business model aims to drive the development of biogas and hydrogen fuel. Hence, Econ’s approach is primarily internally driven as the

company offers green solutions that possess low maturity, with the aim to have a positive environmental impact on the transport industry.

5.4.1.1 Level of motivation

To conclude the above reasonings, the majority of the direct and indirect suppliers are having a combination of a proactive and reactive approach to environmental upgrading, driven by both internal and external drivers. The level of motivation to invest in sustainability to accomplish environmental upgrading can vary depending on if the drivers are external or internal, where internal drivers often lead to stronger motivation (De Marchi & Di Maria, 2019). As described above, many of the suppliers work proactively to target CO2 emissions and work with various fossil-free fuel alternatives deriving from an internal drive and high motivation, creating their own autonomy to develop new solutions. It is nevertheless important to note that the empirical findings show that external drivers e.g. customer demands and regulation also drive environmental upgrading to a certain extent. DB Schenker and Volvo Trucks both mention the increasing awareness and involvement of lead firms (as transport buyers) in regard to greening of transports and fossil-free fuel solutions. This also increases the external drivers on environmental upgrading of suppliers, as it generates a demand which might lead to the suppliers responding by developing and engaging in innovation processes to be able to supply green solutions. However, when external drivers stem from strict transport buyer requirements, one can argue that it might weaken the strong motivation and autonomy of the suppliers to environmentally upgrade as well as inhibit the innovation process of developing new fuel solutions. This is in line with the arguments of captive governance, that as previously mentioned may lock the supplier to the lead firms' requirements which can be set too low compared to what the suppliers are able to perform, and thus inhibit their autonomy.

5.5 The role of inter-firm collaborations in greening

Relationships between GVC actors have become increasingly important as it enables actors to earn greater value (Holm et al., 1999). To create environmental value through greening in a GVC, it has been proven to require cooperation between environmental conscious suppliers and the lead firm of the chain (Wolf & Seuring, 2010). All interviewed GVC actors covered in this thesis, both lead firms and direct and indirect suppliers, are engaged in inter-firm collaborations for greening of road transports in different ways. DB Schenker describe that environmental issues have become more strategically important for transport buyers (i.e. DB Schenker's

customers) and thus they are increasingly engaging in collaborations together to look into new solutions and investments for greener road transportation. Another example strengthening the argument that greening in GVCs requires cooperation is Volvo Trucks that have increasingly started to collaborate not only with its customers (e.g. road carriers) but also its customers' customers (i.e. transport buyers). Moreover, Volvo Trucks highlights how large transport buyers have become a heavier external driving force to address environmental issues in transportation, and are involved to influence current and future technologies, which requires collaboration.

5.5.1 Critical factors of inter-firm collaborations

CompanyX describes that they receive several collaboration requests regarding greening of road transports from other actors, since the company is one of the largest transmitters of goods in the world. CompanyX emphasizes that this results in that they have to prioritize whom to collaborate with and what initiatives to invest in, which is often based on the other actors' ability to influence the market by e.g. larger company size and global reach. Similarly, Volvo Trucks explains that strategic collaborations often involve larger customers, as their strategic agenda and conditions generally align with Volvo Trucks'. Hence, it can be argued that both CompanyX and Volvo Trucks aim to reach compatibility in these collaborations. Compatibility, including unified strategic vision and finances, is one of Ilyas et al. (2007) three cornerstones for creating successful collaborations by achieving a collaborative advantage. Another example of aiming towards compatibility is Preem's collaborations with Swedish forestry companies, which are initiated by common interests.

The second of Ilyas et al.'s (2007) cornerstones is capability, including competence and complementary strengths, which is also a factor that the interviewed GVC actors have shown tendencies of seeking in collaborations regarding greening of road transports. For example, DB Schenker are involved in close collaborations with truck manufacturers, since they possess complementary strengths such as technical competencies for trucks and new fuel solutions. Furthermore, DB Schenker also describes that to drive the transition towards fossil-free transports and developing new fuel solutions, they engage in collaborations including several actors e.g. truck manufacturers, energy suppliers, government and other institutions to create a wide base of complementary competencies. According to Bitzer and Glasbergen (2015), this way of working across sectors and utilizing complementary capabilities leads to jointly addressing issues that would otherwise not be possible by a single party. Thus, using

complementary resources including several factors is an important aspect for driving the transition towards fossil-free fuels for transports, as there are many different aspects (e.g. trucks, infrastructure, fuel supply etc.) required for a full scale transition to a new fuel solution.

The third cornerstone to reach collaborative advantage is commitment, including exit cost i.e. the cost of leaving a collaboration (Ilyas et al., 2007). Both CompanyX and DB Schenker describe that committing to long-term contracts can facilitate collaborations for a new solution. CompanyX can encourage a road carrier to invest in a new solution by committing to longer contracts to assure return on investment for the carrier by securing transport volumes. This creates a joint commitment, and thus an exit cost for both parties. De Marchi et al. (2013a) further strengthen that commitment can facilitate greening, as a stable demand and long-term relationships are emphasized as critical factors.

5.5.1.1 Achieving collaborative advantage

The empirical findings show tendencies for the three cornerstones in the GVC actors' inter-firm collaborations for greening of road transport. However, the findings also reveal that it is a challenge to simultaneously achieve compatibility, capacity and commitment in collaboration regarding fossil-free fuel solutions, due to the many uncertainties, high risks and the global reach. This impacts the ability for the actors to achieve collaborative advantage in the inter-firm collaborations, as Ilyas et al. (2007) emphasize that all cornerstones are essential and must be fulfilled. It is apparent from the empirical findings that it is difficult to predict the future for different fossil-free fuels and the situation can change rapidly. For example, Lidl Sweden describes how the company invested in HVO for its road transports as it was marketed as a good alternative to fossil fuels which also reduced its CO2 emissions. HVO was however found to potentially include harvesting of rainforest, drastically changing the situation and outlook for the fuel. Furthermore, Scania describes that there are concerns regarding the calculation of the actual environmental impact of fuels, creating further uncertainties regarding different fuel alternatives. In accordance with Poulsen et al. (2016), the absence of consistent measurement standards of emission makes it difficult to make reliable comparisons of alternatives. This could imply that although many actors can have a unified vision to lower transport emissions in a collaboration, it can be a challenge to agree to a fossil-free fuel alternative due to the uncertainty, and thus reach compatibility. The results also show that all actors collaborate across sectors to reach capacity and hence make use of complementary strengths, however, committing

large financial resources to invest in a large-scale solution is often associated with high risks and uncertainty.

5.6 Revised conceptual framework

The analysis indicates that the original conceptual theoretical model is supported in regard to how greening of GVCs is addressed from both a lead firm and supplier perspective. Firstly, the GVC mapping should be based on the lead firms GVC and it lays the foundation for who and what that should be analyzed. Secondly, it is evident that the top-down and bottom-up approach are highly interconnected, as the ability to environmentally upgrade affects the governance structure adopted by the lead firm, which in turn influences the opportunity for suppliers to environmentally upgrade. Thus, it is important to consider the two perspectives simultaneously when analyzing greening of GVCs. Thirdly, inter-firm collaborations have also been proven to have a large impact on the greening of GVCs especially when investigating a transition to fossil-free fuels, since many parts must be in place and thus many actors need to be involved to develop a solution.

Nevertheless, it is evident that in the case of greening GVCs through transitioning to fossil-free fuels, the lead firm and supplier characteristics have an impact on the governance structure, sustainability governance and environmental upgrading, but also their inter-firm collaborations. Characteristics such as size of the actors have been proven to influence the power balance between lead firms and suppliers, which impacts what governance structure is adopted by lead firms and the ability for suppliers to environmentally upgrade. Also, the end market for lead firms (B2C/B2B) impacts the level of engagement in sustainability governance. The attitude and drive towards working with fossil-free fuels is another important characteristic that directly impacts the outcome of inter-firm collaboration, as these need to be aligned between the actors. Hence, characteristics of both lead firms and suppliers are important factors that need to be considered as a basis when analyzing the greening of GVCs and have therefore been added to the conceptual framework for both the top-down and bottom-up perspectives in *Figure 9*.

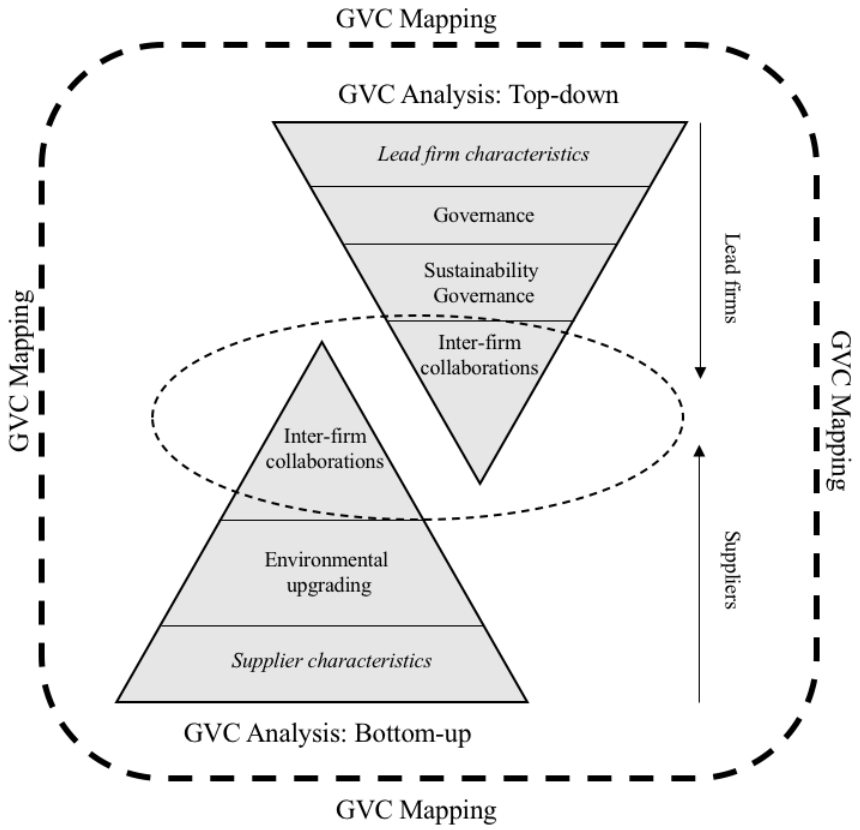

Figure 9. Revised conceptual framework model compiled by authors.

6. Conclusions

This concluding chapter firstly answers the study's research question; "From both a lead firm and supplier perspective, how is greening of GVCs addressed by reducing CO2 emissions from road transports with an emphasis on fossil-free fuels?". Secondly, theoretical contributions and practical implications are presented to further highlight the obtained findings. Lastly, limitations and suggestions for future research are outlined.

This multiple-case study has taken both a lead firm and supplier perspective to examine how greening of GVCs is addressed by reducing CO2 emissions from road transports with an emphasis on fossil-free fuels. The multiple-case study included four lead firms and their respective GVC, and five suppliers within three categories related to road transports (i.e. road carrier, truck manufacturers and energy suppliers) resulting in nine case study objects in total. To comprehensively examine how greening of GVCs is addressed, a conceptual framework was developed. The conceptual framework is grounded on GVC literature, where GVC mapping lays the foundation for the GVC analysis from both a top-down and bottom-up perspective. In addition, insights from GPN literature concerning the network perspective and inter-firm relationships have been added. The empirical data was then analyzed using the conceptual framework, identifying how lead firms govern their road carriers and address sustainability governance, how the suppliers address environmental upgrading as well as how both lead firms and suppliers work in inter-firm collaborations for greening of GVCs. The study mainly adopts a private regulation perspective, focusing on the lead firms' governance of greening GVCs, as the empirical findings were found to support the argument that state regulation has a limited impact when analyzing greening on a global scale.

The result of this study firstly shows that from a top-down perspective, the lead firms mainly adopt captive governance/standard-driven greening in relation to road carriers. The lead firms thus gain control and coordination, as well as drive greening, through applying Code of Conducts and audits on their road carriers. The results further imply that this is due to a combination of factors being the lead firms' characteristics (e.g. size, global spread and heavy volumes of goods), the complexity of the transport industry and reliance on road carriers for the lead firms to reach their environmental goals. Furthermore, the lead firms mainly adopt an internal perspective to sustainability governance, where the two B2C lead firms are engaging in sustainability *of* chains by transferring knowledge and information to their road carriers to a

higher extent than the B2B lead firms due to facing higher reputational risk regarding greening. In addition, only the lead firms operating B2C explicitly mention working with alternative fossil-free fuels as a means for reducing CO2 emissions, further implying that they are more prone to take a higher risk. The external perspective to sustainability governance, however, is not very prevalent among the lead firms in relation to the transition to fossil-free fuels, as it has been proven difficult for the various actors to reach consensus and be willing to carry the related costs due to the high uncertainties.

From a bottom-up perspective, the result of this study shows that the suppliers have a combination of internal and external drivers to environmentally upgrade resulting in a varying degree of proactiveness and/or reactiveness. The level of proactiveness in terms of working with and prioritizing which fossil-free fuels to invest in varies between the different suppliers depending on their characteristics such as strategic intent, capabilities and competencies. The external drivers on both the direct and indirect suppliers have become stronger as lead firms are increasingly aware and involved in regard to greening of transports and fossil-free fuel, generating a greater demand for green solutions resulting in more incentives for suppliers to environmentally upgrade. However, it has been found that when lead firms adopt captive governance with strict requirements, the external drivers could instead weaken the motivation and autonomy of the direct suppliers to environmentally upgrade as well as inhibit the innovation process of developing new fuel solutions. Hence, in the case of greening road transportation through fossil-free fuels, this contradicts the argument that suppliers in buyer-driven chains have large upgrading opportunities as this study shows that when lead firms adopt captive governance, it hinders the road carriers to utilize their full greening capabilities by locking them to the lead firms' strict requirements.

Lastly, it has been evident that the top-down and bottom-up perspective is highly interconnected when analyzing GVCs as governance affects environmental upgrading and vice versa. It is also apparent from the results that lead firms and suppliers are interconnected through involvement in inter-firm collaborations regarding greening of GVCs. However, the findings also reveal that it is difficult to achieve collaborative advantage in collaborations for fossil-free fuels as the characteristics of all GVC actors must comply. Even though lead firms and suppliers engage in cross-sector collaboration to make use of complementary strengths, the challenges are to have a unified vision regarding fossil-free fuel alternatives and committing large financial resources as these aspects are often associated with high risks and uncertainty.

6.1 Theoretical contributions

This study contributes with a more holistic view to analyze greening of GVCs by taking both a top-down and bottom-up perspective, and thus considering sustainability governance and environmental upgrading simultaneously. In addition, by including parts of the network perspective from GPN literature to the existing GVC analysis of greening, this study goes one step further in understanding the interconnectedness between lead firms and suppliers through inter-firm collaborations. Furthermore, this deeper understanding also revealed the significance of the lead firms and the suppliers' characteristics when addressing greening of road transports. By considering the above aspects, a conceptual framework has been suggested to understand and analyze how greening of GVCs is addressed by reducing CO2 emissions from road transports.

To our best knowledge, the literature concerning analyzing greening of GVCs has paid little attention to the negative environmental impacts of transportation (See Poulsen et al., 2016;Poulsen et al., 2018) where no literature focusing on road transports has been found. Therefore, another contribution of the study is the extension of the limited research field focusing on greening of GVCs through transportation, and specifically road transportation.

6.2 Practical implications

The main practical implications that can be drawn from this study are two-fold. Firstly, the study indicates that the governance structure adopted by lead firms influences the environmental upgrading opportunities for suppliers in buyer-driven chains. In this context, it was found that lead firms adopting a captive governance structure on the road carriers may lock the transport supplier to strict requirements and therefore hinder them too environmentally upgrade. This has been proven to be especially true when there is a power imbalance between the lead firm and the road carrier, where the lead firms are large transmitters of goods and the road carrier is eager to keep the lead firms in their customer base. Thus, it is suggested that lead firms and road carriers should to a larger extent work together in close collaborations to discuss different alternatives and requirements to reach the optimal solution for a specific situation. Nevertheless, it is important to note that adopting a more relational governance is time and cost consuming, however, the positive benefits arising from collaborations with road carriers are

essential in order for lead firms to reach their sustainability goals, as the road transport sector causes major CO2 emissions.

Secondly, for large lead firms with heavy volumes it is difficult to have close collaborations with all road carriers, and therefore it is also important to carefully evaluate whom to work closely with. It has been found in this study that characteristics of both lead firms and road carriers are important factors to consider in collaborations regarding greening of road transport in GVCs. With that being said, it is not argued that lead firms should adopt relational governance on all road carriers, instead close collaborations should be carried out with actors possessing certain characteristics that align with or complement the lead firms. Further, this argument is also applicable for other suppliers related to road transport (e.g. truck manufacturers and energy suppliers).

6.3 Limitation and future research

This study investigated how greening is addressed in GVCs, both by lead firms and suppliers, by reducing CO2 emissions from road transports and with an emphasis on fossil-free fuels. However, as presented in *1.5 Delimitations,* there are a limited number of nine GVC actors covered in this study. This limitation affects the generalizability of the findings to be applicable on all lead firms and supplier-categories' respective population. Thus, we suggest that similar studies should be conducted including a larger number of respondents to increase the generalizability.

Additionally, the case companies participating in this study are all Swedish, however with a global presence. The attitude towards greening of road transports and emission reduction has been proven to differ between geographical locations in the GVCs, where Sweden is in the forefront in the country's sustainability development and of becoming fossil-free compared to other countries. This can be argued to have an impact on the answers gained from the respondent and hence the finding's transferability to all geographical markets globally. Therefore, it is also suggested that additional studies similar to this, but with more geographically spread participants should be carried out. Also, this study merely focuses on greening through lowering emissions from road transportation and the suppliers included were narrowed down to three categories related to specifically road transports. Thus, it would be of interest to investigate the transferability of the findings beyond road transportation by conducting studies in different

transportation and greening contexts.

Lastly, through investigating how greening of GVCs is addressed by both lead firms and suppliers, it was found that characteristics of the GVC actors are important factors that need to be considered as a basis when analyzing the greening of GVCs. Therefore, it would be relevant to extend our research by investigating deeper what and how different characteristics of the lead firms and suppliers impact greening of GVCs.

7. Reference list

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Appendix

Appendix 1 - Interview guides

<u>LEAD FIRM (Swedish version)</u>

Allmänt:

- Beskriv din roll på **xx** och vad du gör, samt vilken del av bolaget du tillhör?

Värdekedja

- Vilka är dom huvudsakliga involverade parterna i er värdekedja? *(Från råvara till färdig produkt)*
- Hur styrs värdekedjan, både de interna och externa delarna?

Arbetet med leverantörer

- Hur väljer ni era leverantörer/samarbetspartners?
- Hur ser relationen mellan er och leverantörerna ut?

Hållbarhet och transport

- Vem äger transporterna längst värdekedjan?
- Hur jobbar ni med minimering av utsläpp av transporter?
- Hur ser samarbetet ut mellan logistik (transport) och hållbarhet?
- Är hållbarhetsstrategier centrerade (gäller samma för hela bolaget och/eller värdekedjan?)
- Jobbar ni med omställning till fossilfria bränslen för transporter? (vätgas, biogas, el/batteridrivet)
- Vilka är de största svårigheterna/utmaningarna med att uppfylla hållbarhetsstrategier/mål inom transport i värdekedjan för er?
- Vad tror du krävs för att ni ska ställa om och satsa storskaligt på gröna vätgas transporter inom **xx**?

Sista frågor

- *Finns det någonting ytterligare som ni vill tillägga?*
- *Kan vi höra av oss om vi har uppföljningsfrågor?*

LEAD FIRM (English version)

Generally

- Describe your role at **xx** and what you do, and which part of the company you belong to?

Value chain

- Who are the main parties involved in your value chain? (From raw material to finished product)
- How is the value chain controlled, both the internal and external parts?

Working with suppliers

- How do you choose your suppliers / partners?
- How is the relationship between you and your suppliers?

Sustainability and transport

- Who owns the transports along the value chain?
- How do you work with minimizing emissions from transport?
- What does the collaboration between logistics (transport) and sustainability look like?
- Are sustainability strategies centered (does the same apply to the entire company and / or the value chain?)
- Do you work with conversion to fossil-free fuels for transport? (hydrogen, biogas, electricity / battery powered)
- What are the biggest difficulties / challenges in meeting sustainability strategies / goals in transport in the value chain for you?
- What do you think is required for you to transition and invest on a large scale to green hydrogen transport within **xx**?

Last questions

- *Is there anything else you would like to add?*
- *Can we get in touch if we have follow-up questions?*

ROAD CARRIER (Swedish version)

Allmänt:

- Beskriv din roll på DB Schenker och vad du gör, samt vilken del av bolaget du tillhör?

Fossilfria drivmedel

- Hur jobbar ni med övergången till fossilfria transporter idag? (biodrivmedel, vätgas, el/batteridrivet)
- Ingår ni i några typer av samarbeten/projekt kring fossilfria transporter? (Ge exempel)

- Hur väljer ni vilka samarbeten/projekt kring fossilfria transporter ni ska satsa på?
- Hur ser relationen mellan er och transportköpare ut när det gäller utvecklingen av fossilfria transporter?
- Hur ser relationen mellan er och lastbilstillverkare ut när det gäller utvecklingen av fossilfria transporter?
- Hur ser efterfrågan ut på vätgas lastbilar idag, och vad är det som påverkar efterfrågan?
- Vilka är de största utmaningarna för en expansion till vätgasdrivmedel för transportsektorn för lastbilar?
- Hur ser ni på framtiden för vätgas?

Sista frågor

- *Finns det någonting ytterligare som ni vill tillägga?*
- *Kan vi höra av oss om vi har uppföljningsfrågor?*

<u>ROAD CARRIER (English version)</u>

Generally

- Describe your role at DB Schenker and what you do, and which part of the company you belong to?

Fossil-free fuels

- How do you work with the transition to fossil-free transports today? (biofuels, hydrogen, electricity / battery)
- Are you part of any types of collaborations / projects regarding fossil-free transport?
- How do you choose which collaborations / projects regarding fossil-free transport you should engage in?
- What is the relationship between you and transport buyers when it comes to the development of fossil-free transport?
- What is the relationship between you and truck manufacturers when it comes to the development of fossil-free transport?
- What is the demand for hydrogen trucks today, and what affects the demand?
- What are the biggest challenges for an expansion into hydrogen fuels for the truck transport sector?
- What do you think about the future for hydrogen?

Last questions

- *Is there anything else you would like to add?*
- *Can we get in touch if we have follow-up questions?*

TRUCK MANUFACTURER (Swedish version)

Allmänt:

- Beskriv din roll på **xx** och vad du gör, samt vilken del av bolaget du tillhör?

Fossilfria drivmedel

- Hur jobbar ni med övergången till fossilfria transporter idag? (biodrivmedel, vätgas, el/batteridrivet)
- Hur väljer ni vilka samarbeten/projekt kring fossilfria transporter ni ska satsa på?
- Hur ser relationen mellan er och stora multinationella bolag ut när det gäller hållbarhet?
- Ingår ni i några typer av samarbeten/projekt kring vätgas? (Ge exempel)
- Hur ser efterfrågan ut på vätgas lastbilar idag, och vad är det som påverkar efterfrågan?
- Vilka är de största utmaningarna för en expansion till vätgasdrivmedel för transportsektorn för lastbilar?
- Hur ser ni på framtiden för vätgas?

Sista frågor

- *Finns det någonting ytterligare som ni vill tillägga?*
- *Kan vi höra av oss om vi har uppföljningsfrågor?*

TRUCK MANUFACTURER (English version)

Generally:

- Describe your role at **xx** and what you do, and which part of the company you belong to?

Fossil-free fuels

- How do you work with the transition to fossil-free transport today? (biofuels, hydrogen, electricity / battery)
- How do you choose which collaborations / projects around fossil-free transport you should invest in?
- What does the relationship between you and large multinational companies look like when it comes to sustainability?
- Are you involved in any types of collaborations / projects regarding hydrogen?
- What is the demand for hydrogen trucks today, and what is the effect on demand?
- What are the biggest challenges for an expansion into hydrogen fuels for the road transport sector?
- What do you think about the future of hydrogen?

Last questions

- *Is there anything else you would like to add?*
- *Can we get in touch if we have follow-up questions?*

ENERGY SUPPLIER (Swedish version)

Allmänt:

- Beskriv din roll på **xx** och vad du gör, samt vilken del av bolaget du tillhör?

Fossilfria drivmedel

- Hur jobbar ni med övergången till fossilfria bränslen idag? (biodrivmedel, vätgas, el/batteridrivet)
- Hur jobbar ni med vätgas idag och hur omställningstiden ut för att göra den mer grön?
- Hur ser efterfrågan ut för grön vätgas idag, och hur tror ni att den kommer att förändras inom närmsta framtiden?
- Vilka är de största barriärerna för en fullskalig omställning till grön vätgas för transportsektorn för lastbilar?
- Vilket typ av inflytande anser du att stora producerande (multinationella) bolag har i omställningen till fossilfria drivmedel för transporter, och specifikt för grön vätgas?
- Ingår ni i några typer av samarbeten/projekt kring vätgas?
- Hur ser ni på framtiden för vätgas?

Sista frågor

- *Finns det någonting ytterligare som ni vill tillägga?*
- *Kan vi höra av oss om vi har uppföljningsfrågor?*

ENERGY SUPPLIER (English version)

Generally:

- Describe your role at xx and what you do, and which part of the company you belong to?

Fossil-free fuels

- How do you work with the transition to fossil-free fuels today? (biofuels, hydrogen, electricity / battery)
- How do you work with hydrogen today and how does the conversion time work out to make it greener?
- What is the demand for green hydrogen today, and how do you think it will change in the near future?

- What are the biggest barriers to a full-scale transition to green hydrogen for the truck transport sector?
- What kind of influence do you think large producing (multinational) companies have in the transition to fossil-free fuels for transport, and specifically for green hydrogen?
- Are you involved in any types of collaborations / projects around hydrogen?
- What do you think about the future for hydrogen?

Last questions

- *Is there anything else you would like to add?*
- *Can we get in touch if we have follow-up questions?*

Appendix 2 - Example of cross-case analysis