Roadblocks to Implement Electric Freight Transports

Challenges for Commercial Vehicle Manufacturers and Hauliers

Jorge Gutiérrez Chiriboga
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"Greenhouse gas emissions keep growing. Global temperatures keep rising and our planet is fast approaching tipping points that will make climate chaos irreversible. We are on a highway to climate hell with our foot still on the accelerator"\textsuperscript{1}.

\textit{UN’s Secretary-General’s, Antonio Guterres, remarks to High-Level opening of COP27}

Abstract

The freight transport industry is crucial for the global economy and a key element of all supply chains and logistics systems. The demand for freight is expected to more than double over the next three decades. Freight transport’s externalities and negative impact on the environment have been highlighted in previous research and reports. At the same time, the latest IPCC (2023) report highlights the urgency to dramatically cut emissions to mitigate the effects on climate change caused by human actions, which also relates to freight transport, which in essence is a result of the design and management of supply chains.

A way of reducing GHG emissions from logistics operations is to implement a variety of environmentally friendly strategies, processes, and activities designed to minimize the environmental impact of such operations. Switching to vehicles powered by zero-emission and non-pollutant technology is one of the proposed strategies to reduce the environmental impact of logistics operations.

Electromobility is foreseen to become one of the main pathways to decarbonize supply chains and logistics operations. However, the transition to electromobility entails that many actors in the supply chain are affected. Two important actors in the transition are the Commercial Vehicle Manufacturers (CVMs), as technology providers, and the hauliers, as technology adopters. The implementation of Heavy-duty Battery Electric Vehicles (HBEVs) in road freight transport entails that, as technology providers, and the hauliers, as technology adopters, are exposed to a range of challenges.

The purpose of the thesis is to describe and explain the challenges of implementing BEVs among Commercial Vehicle Manufacturers (CVMs) and Hauliers. This thesis targets the intersection of electromobility and supply chain management and aims to contribute to the body of research on green logistics by investigating manageriaal and business-related aspects of the implementation of HBEVs in road freight transports and to shed light on the subject to practitioners outside academia.

The research has been performed through literature reviews and case studies. The case studies include interviews, document studies and observations from two commercial vehicle manufacturers (of which one is a main case and one is a reference case), and eight haulier companies.

The research reveals that the challenges for both CVMs and hauliers relate to Technology, Finance, Market, Organization and Policy. Further, the challenges take different shape depending on the actor’s perspective, for example, a technology-related challenge for the CVMs such as battery capacity, translates to a technology-related challenge for the hauliers in terms of limited range.

Finally, the challenges can be interrelated and might have a reinforcing effect in many cases, which inhibits, even further, the transition to electrified freight transports. For instance, challenges related to technology have a direct impact on operations and finance. The limited range of HBEVs – a technology challenge – results in a less flexible freight vehicle, that requires a more careful planning from the hauliers’ side – operational challenge. The loss of operational flexibility entails that it’s more difficult for the hauliers to accept unplanned transport assignments from transport buyers, which has a direct impact on the haulier’s earning capacity – a financial challenge.
Sammanfattning

Transportindustrin är avgörande för den globala ekonomin och en viktig del i alla leveranskedjor och logistiksystem. Efterfrågan på godstransporter förväntas mer än fördubblas över de närmaste tre decennierna. Godstransporternas negativa inverkan på miljön har lyfts fram i tidigare forskning och rapporter. Samtidigt understryker den senaste IPCC-rapporten (2023) behovet av att drastiskt minska utsläppen för att mildra effekterna av klimatförändringar som orsakas av mänskliga handlingar. Det gäller även godstransporter, som i huvudsak är ett resultat av utformningen och hanteringen av leveranskedjor.

Ett sätt att minska koldioxidutsläpp från logistikverksamhet är att implementera strategier, processer och aktiviteter utformade för att minimera miljöpåverkan av denna typ av verksamhet. Att övergå till nollutsläppsfordon är en av de föreslagna strategierna för att minska den miljömässiga påverkan av logistikverksamheten.

Elektrifiering förutspås bli ett av huvudspåren för att minska koldioxidutsläpp från leveranskedjor och logistikverksamhet. Emellertid innebär övergången till elektrifiering att många aktörer i leveranskedjan påverkas. Två viktiga aktörer i övergången är fordonstillverkarna (CVMs, engelsk förkortning), som teknikleverantörer, samt åkerierna, som teknikanvändare. Implementeringen av tunga batteridrivna elfordon (HBEVs, engelsk förkortning) i godstransporter innebär att fordonstillverkare och åkerier står inför en rad utmaningar.

Syfte med denna avhandling är att beskriva och förklara utmaningarna med att implementera tunga batteridrivna elfordon för fordonstillverkare och åkerier. Avhandlingen fokuserar på skärningspunkten mellan elektromobilitet och Supply Chain Management, och bidrar till forskningen om grön logistik genom att undersöka lednings- och affärsrelaterade aspekter av implementeringen av tunga batteridrivna elfordon, samt att belysa ämnet för praktiker utanför den akademiska världen.

Forskningen har genomförts genom litteraturstudier och fallstudier. Fallstudierna inkluderar intervjuer, dokumentstudier och observationer från två tillverkare av kommersiella fordon (varav en är ett huvudfall och en är ett referensfall) och åtta åkeriföretag.

Appended papers and case report

Paper I

Paper II
Jorge Gutierrez Chiriboga, Maria Huge-Brodin and Uni Sallnäs (2023). *Implementing Electrified Road Freight – Challenges for Hauliers*. Manuscript for Journal paper (Work-In-progress)

Case report – Scania
Jorge Gutiérrez Chiriboga.
Acknowledgements

Three years ago, when I embarked on this endeavour, I thought that I had a clear path ahead – nothing so far from reality. Today, I understand the meaning of “I know that I know nothing.” I would like to take the opportunity to thank all the people that have been a part of this incredible journey.

First and foremost, I would like to thank Scania for giving me the opportunity to pursue this dream. I want to thank my supervisor at Scania, Magnus Blinge, for his support during these years. I also want to thank all the people within Scania that have opened their doors, and shared knowledge and insights in times of profound transformation in the company.

To Maria Huge-Brodin and Uni Sallnäs, my supervisors at Linköpings University, my deepest gratitude. Thank you for everything: for your patience and support, for all the advices, for pushing me forward and not letting me give up. Without you this thesis could not have been written. I also want to thank all at the Logistics and Quality Management division for making me feel welcome from the first day. To Priscilla, Macy, My, Sabrina, Daan and Niklas, thank you for all the laughing moments.

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Jorge Gutiérrez Chiriboga
Tullinge, February 2024
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1. Introduction

In this chapter the background to the thesis is presented. The background leads on to the thesis’ purpose and the research questions. The chapter concludes with a short outline of chapters in the thesis.

1.1 Background

The freight transport industry is crucial for the global economy and a key element of all supply chains and logistics systems. The demand for freight is expected to more than double over the next three decades (ITF 2021). Freight transport’s externalities and negative impact on the environment have been highlighted in previous research and reports (IPCC, 2022; ITF, 2021). For instance, freight transport accounted for over 40% of transport emissions in 2019 ITF (2021). Moreover, the latest IPCC (2023) report highlights the urgency to dramatically cut emissions to mitigate the effects on climate change caused by human actions, with freight transport being a prominent example. Against this background, the need for reducing emission of greenhouse gases (GHG) and their effects on global warming is of severe importance. Furthermore, the freight transport sector is considered to be one of the most challenging economic sectors to decarbonize because of the energy intensity of freight transports, as well as the CO2 intensity of freight transport energy (Guérin et al., 2014). Road freight transport accounts for for more than 15% of global oil demand today IEA (2022). In addition, 68% of surface freight worldwide is carried by road vehicles, accounting for 73% of GHG emissions coming from freight transports ITF (2022).

In line with these reports the need to decarbonize supply chains and logistics operations has been stressed (see for example McKinnon et al., 2015; McKinnon, 2018). A way of reducing GHG emissions from logistics operations is to implement a variety of environmentally friendly strategies, processes, and activities designed to minimize the environmental impact of such operations. These practices are often referred to as Green Logistics Practices (GLPs) and entail a variety of activities such as reducing the demand for freight movement, shifting freight to lower-carbon transport modes, improving asset utilization, increasing energy efficiency, and switching to lower-carbon energy (McKinnon, 2018). Thus, switching to lower-carbon energy by switching to vehicles powered by zero-emission and non-pollutant technology is one of the proposed strategies to reduce the environmental impact of logistics operations.

In this context, electromobility – defined in this thesis as the use of vehicles powered by electricity to carry out road freight transport – is emerging as one of the main pathways to decarbonize logistics and supply chain operations (EEA, 2022; ITF, 2023). Electromobility consists of different technical solutions e.g. fuel cell technology, Electric Road Systems (ERS) or Battery Electric Vehicles (BEVs) (ITF, 2022). However, the transition to electromobility is a multidimensional challenge that is radical and systemic Altenburg et al. (2012). It is radical because it entails the introduction of completely new core technologies; and systemic because it entails the emergence of new subsystems, new institutions and new power relations (ibid). The challenges of the transition to electromobility relate, among other aspects, to technology.

\[\text{https://read.oecd-ilibrary.org/transport/itf-transport-outlook-2021_16826a30-en#page169} \text{ (2023-01-18)}\]

Commercial Vehicle Manufacturers (CVMs), are in the midst of a tremendous technology shift from Internal Combustion Engine (ICE) technology to electromobility, and face challenges concerning supply chains (Richert and Dudek, 2023), new actors and constellations in the industry; product development and battery technology (Altenburg et al., 2016; Mule et al., 2021), the aftermarket business (Dombrowski and Engel, 2014; Ropin and Supan, 2020), and the necessity to reinvent their business models (Tungur and Engwall, 2014). Likewise, the transition to electromobility affects the entire freight transport sector. The introduction of electric Light Commercial Vehicles in the last decade was the starting point of a transition that has gained momentum and is reflected by the growing number of new registrations of these types of vehicles (Tsakalidis and Thiel, 2018). Hauliers have tested and evaluated the new technology, mainly electric Light Commercial Vehicles in urban contexts, and faced challenges related to costs and investments, range, charging infrastructure, operations and policy among others (Dong et al., 2018; Hovi et al., 2020; Melander et al., 2022). The conditions for carrying out freight transports are not the same as with conventional commercial vehicles, based on ICE-technology, which creates a necessity for new approaches and new solutions from their side regarding planning, routing, pricing and business models as well (Quak et al. 2016; Dong et al., 2018).

The introduction of electromobility into the heavy-duty commercial vehicle market segment, enabled by advances in battery technology, in the form of Heavy-duty Battery Electric Vehicles (HBEVs) is an additional step in the decarbonization journey of logistics operations. Two crucial actors in the electrification journey of logistics operations and the implementations of HBEVs in road freight transport are CVMs, as technology providers, and the hauliers, as technology adopters. CVMs provide businesses and industries, among them the freight transport sector, e.g. the hauliers, with specialized vehicles solutions (trucks) to transport goods. Hauliers, on the other hand, carry out the transportation of goods and cargo from one location to another using the trucks. The interface between these actors is the arena where many of the challenges related to the implementation of HBEVs need to be managed, short-term, and overcome long-term. Failing in solving these challenges will inhibit the implementation of electromobility and thereby delay the transition to zero-emission and non-pollutant technology by the hauliers, which is crucial for reducing carbon dioxide emissions in logistics operations.

Previous research on challenges of implementing electromobility in road freight transport is based, to a large extent, on studies focusing on light commercial vehicles (Quak et al. 2016; Dong et al., 2018; Imre et al., 2021; Melander et al., 2022). Equivalent studies, focusing on the challenges of implementing HBEVs in road freight transport are limited today – empirical studies are largely absent – due to the novelty of these trucks on the market and the limited number of HBEVs being operated. The body of research on HBEVs has mostly focused on technological aspects (Mareev et al. 2017; Forrest et al., 2020; Nykvist and Olsson, 2021).

In addition, research in Supply Chain Management (SCM) has focused on the relation between actors in the product supply chain and the transport provision chain (see Figure 1). The relationship of CVMs to the transport provision chain has received little attention so far (Gutierrez et al., 2021). The lack of research incorporating the actors’ perspectives to better understand the electrification of transport and logistics systems has been highlighted (Gillström
et al., 2023). As a consequence, the actors’ perspective in the implementation of HBEVs has not been thoroughly studied. For instance, research focusing on the role of the CVMs, as technology providers, in relation to the hauliers, as technology adopters, and in relation to the hauliers’ customers, the transport buyers, is missing. Also, the managerial and business-related challenges faced by CVMs and hauliers when implementing HBEVs have not been in focus, which is imperative in times of fundamental technology shifts. These insights are crucial to understand the nature of the challenges faced by these actors when implementing HBEVs in freight transports, the interrelation of the challenges, and their effect on the transition to the new vehicle technology.

![Figure 1. A supply chain structure – Adapted from Huge-Brodin and Sweeney (2021)](image)

1.2 Purpose and research questions

According to the argumentation above, the implementation of electromobility, and in this specific case the implementation of HBEVs in road freight transports entails a diversity of challenges for CVMs and hauliers. Moreover, the relationship of the CVMs to the transport provision chain has not been thoroughly studied in previous SCM research (Gutierrez et al., 2021). Furthermore, there is a lack of research that incorporates the actors’ perspective in the electrification of transport (Gillström et al., 2023). Consequently, there is a need to incorporate the perspectives of the CVMs and hauliers to understand the challenges faced by them when implementing HBEVs, as well as the role of the CVMs in relation to the throughout the implementation. A clear understanding of the nature of the encountered challenges, their interrelation and their effect is fundamental and a prerequisite to prevent these challenges from becoming barriers. In this context, a challenge has a dynamic connotation, it can be overcome, while a barrier has a static connotation in that it prevents movement or advancement.
Consequently, this thesis aims to contribute to the electrification journey of road freight transports by focusing on the challenges of implementing HBEVs for two important actors. Therefore, the purpose of this thesis is to:

**Describe and explain the challenges of implementing HBEVs for Commercial Vehicle Manufacturers and Hauliers.**

In order to describe the challenges of implementing HBEVs, identifying and classifying the perceived challenges from the perspective of the CVMs and the perspective of the hauliers is crucial to understand the nature of the challenges, the degree of urgency of each one of them, and to frame the context in which HBEVs are being implemented. Therefore, the first research question aims to help us in this quest.

**RQ 1. How can the main challenges of implementing HBEVs be described?**

Literature suggest that transition to electromobility is a multidimensional challenge (Altenburg et al., 2012), but also that the challenges are interrelated (Noel et al., 2020). This implies that the transition to electromobility relates to different aspects, as well as the existence of interrelations between and among these aspects. The challenges of implementing HBEVs in road freight transport are presumably not an exception. Moreover, although Altenburg et al. (2012) takes a system perspective, and Noel et al. (2020) a socio-technical perspective, their contributions call the attention to an area that need to be further explored – the multidimensionality of the challenges and their interrelatedness from the actors’ perspective. Interrelatedness in this thesis, refers to the interrelations of the challenges between actors, but also across identified categories of challenges.

Consequently, in order to explain challenges of implementing HBEVs, understanding the interrelatedness between and among them, it is essential to understand the complexity of the implementation of HBEVs, as well as the effect the challenges might have on each other. The second research question aims to shed light on this issue.

**RQ 2. How can challenges of implementing HBEVs be interrelated?**

By answering the two research questions, the purpose of the thesis will be addressed. First, identifying and classifying the challenges is a prerequisite to be able to describe them. Second, having a classification of the challenges in place will allow the contrast, the illustration and explanations of interrelations between and among the challenges. Thus, the relation between the research questions implies that they need to be answered sequentially.
1.3 Outline of the thesis

This thesis is a compilation thesis consisting of a thesis frame, two papers and one case report – all of which are appended in this licentiates thesis. The papers consist of a conference paper and the working paper of a manuscript for a journal article. The thesis frame can be read separately and comprehensibly but is built upon the appended papers and case report. The structure of the remainder of this thesis is as follows:

Chapter 2
In this chapter the frame of reference used for the analysis of the empirical results is presented.

Chapter 3
In this chapter the research approach, the research design and the research methods are presented. The chapter concludes with a presentation of the research quality.

Chapter 4
In this chapter the case companies are presented.

Chapter 5
In this chapter summaries of the appended papers in this thesis are presented. In addition, the contribution of each one of the papers to the thesis is explained, as well as the author’s contribution.

Chapter 6
In this chapter the empirical findings are analysed using the frame of reference.

Chapter 7
In this chapter conclusions and future research are presented
2. Frame of Reference

This chapter presents the frame of reference. It is divided into two sections. The first section presents the challenges of implementing environment-oriented practices. The second section presents the impact of the transition from ICE technology to electromobility within the automotive industry, specifically CVMs.

2.1 Challenges of implementing environmental oriented practices

Environment-oriented practices, or green practices, are strategies, initiatives and methods used by companies to reduce the negative impact of their operations, products and services on the environment (González-Benito and González-Benito, 2005; Montabon et al., 2007; Uhlaler et al., 2012; Ngo, 2023). Although considered important, the implementation of environment-oriented practices faces challenges of different nature (Montalvo, 2008; Walker et al., 2008; Murillo-Luna et al., 2011; Mudgal et al., 2011).

Practices within industries aiming to reduce the environmental impact of logistics operations – transport, and storage and handling of physical goods – are referred as Green Logistics Practices (GLPs). These practices include a variety of activities in different areas, e.g. vehicle use, vehicle technology, transport modes and intermodality, energy efficiency, recycling materials and packaging, supply chain re-organization, supply chain collaboration, reducing the environmental impact of warehousing (Evangelista, 2014; Martinsen and Huge-Brodin, 2014; McKinnon, 2015). GLPs have been the subject of research from different perspectives and in different contexts (see, e.g. McKinnon, 2010; Martinsen and Huge-Brodin, 2014; Huge-Brodin et al., 2020; Björklund et al., 2017; Bask et al., 2018; Gatta et al., 2019; Jazairy, 2020).

Road freight transport are often highlighted as the major source of emissions of greenhouse gases within logistics (ITF, 2021; EEA, 2022). In this context, GLPs aiming to lessen road freight transports’ negative impact on the environment are essential. The use of less polluting vehicles, alternative fuels or biofuels, or new vehicle technology are among proposed GLPs to reduce road freight transports’ externalities and negative impacts on the environment (McKinnon, 2010; Perotti et al., 2012; Colicchia et al., 2013; Martinsen and Huge-Brodin, 2014). However, implementing GLPs in logistics contexts is not an unproblematic endeavour. Although the body of research on the challenges of implementing GLPs is not extensive (Centobelli et al., 2017), it reflects the fact that challenges can be of different nature and vary depending on the context in which GLPs are being evaluated. Table 1 shows a selection of papers dealing with challenges affecting the implementation of GLPs.
Table 1. Papers dealing with challenges of implementing GLPs

<table>
<thead>
<tr>
<th>Paper</th>
<th>Context</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oberhofer and Dieplinger (2014)</td>
<td>Transport and logistics sector in Austria</td>
<td>Size of the firm, lack of resources (financial, know-how, time); pricing pressure; high competition</td>
</tr>
<tr>
<td>Ho et al. (2014)</td>
<td>Logistics companies in China</td>
<td>Investments costs, Size of the firm; Complexity of green initiative</td>
</tr>
<tr>
<td>Evangelista (2014)</td>
<td>Transport and LSP in Italy</td>
<td>High investment cost and lack of financial resources; doubtful payback; lack of human resources; lack of ICT skills; lack of customers' environmental awareness; lack of financial incentives; lack of well-defined regulations framework</td>
</tr>
<tr>
<td>Perotti et al. (2015)</td>
<td>3PLs in Italy</td>
<td>High investments; lack of competences; scarce or negative economic impact; difficulties in identifying and measuring costs/benefits; customers' scarce interest in green products and services; suppliers' scarce interest in green products and services</td>
</tr>
<tr>
<td>Abbasi and Nilsson (2016)</td>
<td>LSP in Scandinavia</td>
<td>Managerial complexity (difficulties in measurement and assessment; finding cooperative ways to develop solutions; complexity of implementation); customer priorities (customers' low interest in more sustainable solutions); network imbalances (restrictions in the system, imbalances in goods and resources flows); technological and legislative uncertainties</td>
</tr>
</tbody>
</table>

Despite the fact that the challenges presented in Table 1 do not appear in all the papers, a certain similarity in the nature of the challenges can be perceived, although it is named differently. For instance, it can be perceived that challenges such as investments costs (Ho et al., 2014), doubtful payback (Evangelista, 2014), scarce or negative economic impact (Perotti et al., 2015), refer to financial constraints, or that challenges such as the size of the firm (Oberhofer and Dieplinger 2014), lack of human resources (Evangelista, 2014), lack of competences (Perotti et al., 2015), managerial complexity (Abassi and Nilsson, 2016) refer to organizational constraints. Thus, challenges can be clustered and classified in different ways. Lin and Ho (2010) classify challenges into three categories: technological, organizational and environmental, in a study among logistics companies in China. Abassi and Nilsson (2016) use four categories to classify challenges: managerial complexity, customer priorities, network imbalances and technological and legislative uncertainties, in a study among Logistics Service Providers (GLPs) in Scandinavia. Jovanovic et al. (2020) classify the challenges in the Canadian trucking sector into five categories: technology, finance, market, organisation and government.

Given the scope of this thesis – the challenges of implementing heavy battery electric vehicles and the fact that a recurring environmental oriented practice is the use of less polluting vehicles or new vehicle technology (Perotti et al., 2012; Colicchia et al., 2013; Martinsen and Huge-Brodin, 2014; Osman et al., 2022), it appears that the frame proposed by Jovanovic et al. (2020) encompass a set of categories that covers most of the challenges faced by the trucking sector, the hauliers, when implementing green initiatives, e.g. Heavy-duty Battery Electric Vehicles (HBEVs) in road freight transports. Consequently, the five categories proposed by Jovanovic et al. (2020) – technology, finance, market, organization and government – will be used to classify the challenges of implementing HBEVs in road freight transports henceforth. To facilitate the classification of the challenges, the government-related challenges will be referred to as policy-related challenges.
The challenges related to each one of the above-mentioned categories will be described from two perspectives: challenges of implementing GLPs in logistics contexts in general, and challenges of implementing electromobility – with both perspectives relating to each one of the five categories. While the former provides a framework for describing the challenges of implementing GLPs within each category, the latter contextualizes the challenges of implementing the technology (electromobility) itself in relation to each category.

Furthermore, due to the novelty of HBEVs on the market, the body of research on challenges of implementing these types of trucks is very limited. Most of the literature on challenges related to electromobility is based, to a large extent, on studies focusing on general challenges in the adoption of electromobility, electric passenger cars in consumer markets, or light freight vehicles operating in urban logistics. Thus, terms such as Electric Vehicles (EV), Electric Freight Vehicles (EFVs), electric Light Commercial Vehicles (eLCVs), Battery Electric trucks (BE-trucks) will appear throughout the following sections.

2.1.1 Technology-related challenges

From a technology perspective, there are several factors influencing the implementation of environment-oriented practices in logistics systems. For instance the complexity and compatibility of the technology (Lin and Ho, 2011; Ho and Lin, 2012) as well as the risks connected to it (Jovanovic et al., 2020; Takman and Andersson-Sköld, 2021) are key factors affecting the implementation of environment-oriented practices. From this perspective, companies tend to implement technologies/practices that are perceived as less complex, more compatible and easy to integrate into present business operations (Lin and Ho, 2011).

The technology-related challenges connected to the implementation of electromobility in road freight transports entails several technical and operational restrictions. For instance the limited battery capacity that limits the vehicles’ range has been highlighted as one of the most important challenges connected to electromobility. Limited range has been pointed out as a challenge, for example by Moultak et al. (2017) when comparing zero-emission heavy-duty vehicle technology worldwide; Anderhofstadt and Spindler (2019) when studying factors influencing the decision to purchase alternative fuel-powered heavy-duty trucks in Germany; Tsakalidis et al. (2020) in the city logistics context with eLCVs; Noel et al. (2020) in a study on challenges for EV in the Nordic countries; and Melander et al. (2022) in a study on EFVs in Stockholm. The limited range in combination with required charging time represent an operational challenge for the hauliers because they reduce the flexibility of the trucks, i.e. EVs cannot be used the same way as conventional trucks. This has been raised, for example, by Dong et al. (2018) in a study comprising EFVs in urban logistics; and Netzer et al. (2022) in a study on the effects of e-highways on battery capacity and charging infrastructure for freight transports in constructions logistics in Austria. Furthermore, the weight and size of batteries have a negative impact on the vehicles load-carrying capacity – the payload. Reduced payload has been highlighted by Quak et al. (2016) for EFVs in a city logistics context; as well as Moultak et al. (2017); Netzer et al. (2022); and Melander et al. (2022).

In addition, the lack of charging infrastructure is considered to be one of the main challenges inhibiting the implementation of electromobility in road freight transports (Quak et al. 2016; Dong et al., 2018; Hovi et al. 2019; Melander et.al, 2022). The deployment of charging infrastructure though faces a chicken and egg dilemma (Zink et al., 2020), that affects the pace of the deployment of the infrastructure – the interrelation between the size of the rolling fleet
and the size of the network of charging stations, (i.e. without a sufficiently large fleet of vehicles on the roads, the incentive to invest in infrastructure is held back due to lack of profitability). Conversely, the lack of charging infrastructure inhibits the implementation of electromobility (Altenburg et al. 2012; Burkert and Schmuelling, 2019). In line with these results, Takman and Andersson-Sköld (2021) also found the interrelation between the rolling fleet and available infrastructure in a study on the diffusion of liquefied biogas for heavy trucks, which corroborates the mutual impact of the rolling fleet and the deployed infrastructure. Additionally, another take on the challenge of the lack of infrastructure is related to the complexity of planning the charging infrastructure due to lack of operational data, as it is crucial to understand where the infrastructure should be deployed (Burkert and Schmuelling, 2019; Zink et al., 2020).

Furthermore, the limited product offering, i.e. limited availability of BEVs-models, as well as the fact that there are other competing alternative technologies such as HVO and biogas are considered challenges that inhibit the implementation of electric freight vehicles (Melander et al., 2022).

2.1.2 Finance-related challenges

Financial challenges when implementing GLPs are mainly related to two issues: the high investments costs, and the lack of financial resources. The high investments costs are a major challenge when carrying out projects aiming to implement GLPs (Rossi et al., 2013; Evangelista, 2014; Perotti et al., 2015). The lack of financial resources to embark on projects that require extensive capital investments represents a challenge to a majority of companies (Evangelista 2014; Oberhofer and Dieplinger, 2014), risk aversion or difficulties identifying and measuring cost and benefits (Perotti et al., 2015), e.g. the uncertainty of the payback period of the investments (Ho et al., 2014; Evangelista et al. 2017; Jovanovic et al. 2020), and the Return on Investment (ROI) (Jovanovic et al. 2020).

From a financial point of view, implementing electromobility in road freight transport entails several economic restrictions and cost concerns due to the high purchasing price of EFVs in comparison to conventional trucks. This challenge has been raised in several studies and different contexts: Quak et al. (2016) for EFVs in city logistics; Hovi et al. (2020) for BE-trucks in Norway; Imre et al. (2021) for EFVs in urban freight transport and city logistics in Turkey; and Melander et al. (2022) for EFVs in city logistics in Stockholm. Moreover, the investment cost of the required charging infrastructure, to be able to operate the vehicles at all, is another important cost element when implementing EFVs (Moultak et al., 2017; Melander et al. 2022). Additionally, another crucial element regarding cost is the high uncertainty regarding the vehicles’ residual value – the price of the truck in a second-hand market – due to lack of operational experience in battery degradation and durability, as well as the absence of a second-hand market. This has been highlighted by Quak et al. (2018) for EFVs in a city logistics context; Anderhofstadt and Spindler (2019) when studying factors influencing the decision to purchase alternative fuel-powered heavy-duty trucks in Germany; Tsakalidis et al. (2020) in the city logistics context with, and eLCVs; Xia et al. (2022) in a study focusing on factors influencing electric vehicles adoption. Furthermore, from a Total Cost of Ownership (TCO) perspective – a critical purchase criterion for the hauliers – the high purchasing price and the uncertainty regarding the residual value have a negative impact on it, and contribute to impair
the conditions for the implementation of electromobility in logistics contexts (Quak et al., 2016; Dong et al., 2018; Imre et al., 2021). A way of improving the TCO is to increase the utilization rate of the truck to offset the high purchasing price of electric freight vehicles by the lower operational cost, i.e. the more kilometres the truck operates, the higher the offsetting effect and improvement. This has been highlighted, for instance by, Dong et al. (2018) in a study comprising EFVs in urban logistics; and Hovi et al. (2020) for BE-trucks in Norway.

2.1.3 Market-related challenges

Market challenges when implementing GLPs relate to several factors. The lack of customer awareness and customer interest in green services/transports is considered a challenge affecting the demand for green services/transports (Perotti et al. 2015; Abbasi and Nilsson, 2016; Evangelista et al., 2017; Bask et al., 2018; Takman and Andersson-Sköld, 2021). In addition, competitive pressure plays a significant role in the implementation of GLPs. The structure of the transport sector has been raised as a determinant factor (Oberhofer and Dieplinger, 2014; Jovanovic et al., 2020). The transport sector is a highly competitive market (Rossi et al., 2013; Oberhofer and Dieplinger, 2014; Evangelista et al., 2017) and is characterized by price pressure, small margins and cost efficiency (Oberhofer and Dieplinger, 2014; Evangelista et al., 2017; Takman and Andersson-Sköld, 2021). Moreover, restrictions in the systems in terms of delivery time and diverse load and unload operations have a negative impact on fill rates and resource utilization (Abassi and Nilsson, 2016). Furthermore, logistics companies often find it difficult to get extra pay for environmentally friendly services/transports (Abassi and Nilsson, 2016; Bask et al., 2018; Jazairy, 2020; Takman and Andersson-Sköld, 2021), as well as to secure long-term contracts with transport buyers (Kacioui-Maurin et al., 2015; Jazairy, 2020). These two challenges – getting extra pay and securing long-term contracts – are particularly important to secure income streams to fulfil the financial commitments related to the investments.

From a market perspective the body of research on the challenges of implementing electromobility in road freight transport is limited partly, because of the novelty of this type of truck in the market. However, Imre et al. (2021) highlight the difficulty “to practically observe a significant relationship between a fleet owner’s environmentally friendly practices and its clients’ consumption decisions” (ibid, pp.7) which implies a lack of interest for greener transports from the transport buyers’ side. Moreover, the limited willingness to pay for electrified freight transports has been noticed by Quak et. al (2016) and Dong et al. (2018) in a studies comprising EFVs in urban logistics. Furthermore, in a study concerning the diffusion of biogas for heavy trucks Takman and Andersson-Sköld (2021) highlighted the difficulty of getting extra pay for biogas-driven transports as well as the lack of demand for renewable fuels from customers outside the public sector.

2.1.4 Organization-related challenges

Organizational challenges relate to several factors. First, the lack of employees and the quality of human resources, i.e. lack of knowledge, competence and experience, are inhibitors when implementing environmentally friendly practices in logistics systems (Lin and Ho, 2011; Ho and Lin, 2012; Oberhofer and Dieplinger, 2014; Evangelista, 2014; Evangelista et al., 2017).
For instance, this may involve the managerial complexity of coordinating customer demands, finding cooperative ways across logistics networks and leading change, as highlighted by Abassi and Nilsson (2016), or the lack of ICT skills for managing green initiatives (Evangelista, 2014). Second, the lack of organizational and management support plays a crucial role in the adoption of green practices. Without these two important elements, it is difficult to get the required resources and the required coordination throughout an organization (Lin and Ho, 2011; Ho and Lin, 2012; Jovanovic et al., 2020). Finally, a company’s size is critical to the implementation of green practices. Large companies usually have sufficient resources to carry out the implementation of green practices, while small companies often lack resources – organizational and financial – which results in difficulties implementing green practices (Oberhofer and Dieplinger, 2014; Lin and Ho, 2011; Ho and Lin, 2012; Ho et al., 2014).

From an organizational perspective, the challenges of implementing electromobility in road freight transports stem from the operational restrictions connected to the limited range and reduced payload as well as the lack of infrastructure as highlighted, for instance, by Dong et al. (2018) in a study comprising EFVs in urban logistics; and Netzer et al. (2022) in a study on the effects of e-highways on battery capacity and charging infrastructure for freight transports in constructions logistics in Austria. These limiting factors make EFVs a less flexible transport solution for the hauliers. Consequently, implementing EFVs requires new ways of managing distribution (Melander et al., 2022) as well as considerable planning to tailor the routes where the trucks can operate (Hovi et al., 2020). Moreover, the lack of route planning software to support hauliers when defining suitable routes for EFVs based on charging possibilities and the required charging time impairs even more the implementation of electrified freight (Quak et al., 2016; Melander et al., 2022).

Furthermore, the lack of trust, information and knowledge can result in potential institutional resistance and aversion to new technologies and change among stakeholders (Imre et al., 2021) due to conservatism in the transport sector (Dong et al. 2018). Similar findings were presented by Takman and Andersson-Sköld (2021), when studying biogas diffusion, where “pure conservatism and ingrained habits” (ibid, pp. 57) were identified as inhibitors to the implementation of liquified biogas for heavy trucks.

2.1.5 Policy-related challenges

Policy-related challenges refers to several factors. First, the lack of uniformity across government bodies is considered a challenge. In this context, conflicting policies across regions or countries can act as inhibitors to the implementation of environmentally friendly transports (Takman and Andersson-Sköld, 2021). Moreover, policy uncertainties due to the absence of clear, stable and long-term directions for policy and regulations from policy-makers are highlighted as a major challenge for carrying out long-term and costly investments (Abbasi and Nilsson, 2016; Evangelista et al., 2017). Finally, the lack of financial incentives to support the implementation of environmentally friendly services/transport and ease the burden of initial investments, e.g. costly technology, is considered to be another critical challenge and major inhibitor (Oberhofer and Dieplinger, 2014; Evangelista et al., 2017; Takman and Andersson-Sköld, 2021).
Policy and regulations are considered to be challenging areas for the implementation of EFVs (Melander et al., 2022). Altenburg et al. (2012) highlight the coordinating role of policy for the transition to electromobility in ensuring that desired activities, e.g. investments, take place. The lack of clarity and predictability in political directives is considered to be a challenge for the implementation of EFVs (Melander et. al, 2022; Imre et al., 2022), since clear, long-term and stable policy is key (Takman and Andersson-Sköld, 2021; Imre et al., 2021). Moreover, from European perspective, the lack of homogeneity in policies and regulations, across regions and countries in, e.g. emission and traffic regulations, is considered a challenge as well (Biresselioglu et al., 2018; Imre et al., 2021; Melander et al., 2022). In addition, uncertainty about policies concerning taxes, subsidies and financial incentives (Melander et. al., 2022) has also been identified as a challenge. Furthermore, uncertainty about the preferred technological pathway of politicians is considered a challenge for the implementation of EFVs (Melander et. al, 2022).

2.2 The impact of the transition to electromobility on the technology providers

The transitioning to electromobility is a multidimensional challenge that is radical and systemic (Altenburg et al., 2012). It is radical because it entails the introduction of completely new core technologies, and systemic because it entails the emergence of new subsystems, new institutions and new power relations between industry actors (ibid). Figure 2 illustrates an adaptation of the three-layers model presented by Wandel et al. (1992). The original model consisting of freight flow, transport network and transport infrastructure has been complemented by the inclusion of two other systems – the technology system, where CVMs operate, and the government system, where governmental institutions are responsible for policy-making e.g. regulations, subsidies and taxations among others. In the model the market for HBEVs solutions can be found in the interface between the hauliers, who represent the transport network, and the CVMs – the technology providers. Although the focus of this thesis is shown by the demarcated area, literature on challenges of implementing GLPs and challenges of implementing electromobility indicate that actors in the remaining layers (transport buyers, represented by the freight flow layer, and charging infrastructure providers – charging equipment providers, grid owners and electricity providers, represented by the transport infrastructure layer) are key to the implementation of electromobility in road freight transports.

![Figure 2. Three layers of freight transport from an implementation perspective (adapted from Wandel et al. (1992))](image-url)
The transition to electromobility is the major technological shift in the automotive industry since the development of ICE technology and entails several challenges for incumbent companies, as technology providers. These companies are referred to in the existing literature by different names: car manufacturers (Aggeri et al., 2009), automakers (Sarasini, 2014), automotive companies (Altenburg et al., 2016), automobile manufacturers (Mule et al., 2021), heavy vehicle manufacturers (Werner et al., 2022). For instance, electromobility requires the development of new core technologies, such as battery technology, electric motors and inverters (Altenburg et al., 2016) – areas outside the traditional competence bases of incumbent companies. This implies that new knowledge, skills and capabilities need to be developed or incorporated by the incumbent companies to make the transition to electromobility in a successfully (Sarasini, 2014; Altenburg et al., 2016). Moreover, as the transition to electromobility is radical and systemic, it requires innovations in interrelated core technologies, charging infrastructure, mobility concepts and the interface with the energy system (Altenburg et al., 2012). All these circumstances have led to the establishment of strategic alliances between incumbent companies in the automotive industry and non-traditional actors, to incorporate new capabilities, accelerate the development pace and secure production capacity (Sarasini, 2014; Altenburg et al., 2016; Mule et al., 2021) and let to more advance learning mechanisms such as market experiments and exploratory partnerships (Aggeri et al., 2009).

Furthermore, implementing electromobility implies that heavy vehicle manufacturers have to change the way the trucks are commercialized in order to gain trust and overcome uncertainties regarding the technology among customers and regulators (Werner et al., 2022). Finally, the implementation of electromobility will impact important parts of the traditional business model negatively, e.g. the profitable aftermarket business, because EVs have fewer moving parts and therefore are less susceptible to wear and tear and, which implies less sold workshop hours and reduced spare parts sales (Dombrowski and Engel, 2014).
3. Methodology

This chapter presents the research methodology. First, the research approach is presented, followed by a presentation of the research process. Thereafter, the research design and research methods are presented. The chapter concludes with a presentation of the research quality.

3.1 Research approach

The purpose of this thesis is to Describe and explain the challenges of implementing HBEVs for Commercial Vehicle Manufacturers and Hauliers. As stated in the two previous chapters, previous research on the implementation of electromobility in road freight is based, to a large extent, on the implementation of electric Light Commercial Vehicles in urban contexts (Quak et al., 2016; Dong et al., 2018; Imre et al., 2021; Melander et al., 2022). Moreover, the relationship of CVMs to the transport provision chain has received little attention (Gutierrez et al., 2021). Consequently, the actors’ perspective, specifically the role of the CVMs, as technology providers, in relation to the hauliers, as technology adopters, when implementing HBEVs in road freight, has not been studied. Thus, the interface between these two crucial actors for the implementation of Heavy-duty Battery Electric Vehicles (HBEVs) in road freight is rather unexplored. Because of this, the overarching research approach of the research project is of an explorative nature. Explorative approaches are recommended when the phenomenon being studied is new, not well-known or have not been studied in depth (Arnbor and Bjerke, 1997; Patel and Davidson, 2011).

While the overarching research approach is of an explorative nature, an inductive research process has been used to achieve the purpose of this thesis. Research studies can be conducted from a deductive, inductive or abductive stance (Bell et al., 2019; Patel and Davidson, 2011). Deductive studies have existing theories as the starting point, from which hypotheses are deduced and tested empirically, while inductive studies have specific observations as a basis for drawing generalizable conclusions. In other words, deductive studies aim to test an existing theory, while inductive studies aim to develop a theory. Abductive studies, on the other hand, combines deductive and inductive reasoning and allows the researcher to move back and forth between empiricism and theory (Bell et al., 2019). The research conducted for this thesis has focused on the challenges of implementing HBEVs. The research has been conducted inductively to a large extent – using interviews, informal conversations and document studies as guidance and as a compass throughout the whole process. Nevertheless, there have been abductive instances in the research as well, for instance, when literature on barriers and electromobility has been incorporated to be able to describe and categorize findings as research has progressed.

To support the research process for this thesis, the research questions to be answered in the thesis frame reflect the descriptive and explanatory nature of the thesis’ purpose. Descriptive approaches are recommended when the objective is to identify characteristics, frequencies, categories or relations within the phenomenon being studied (Patel and Davidson, 2011). Explanatory approaches are recommended when the objective is to establish causal relations between observations (Arnbor and Bjerke, 1997). The first research question aims to describe
the challenges of implementing HBEVs from the CVM and the hauliers’ perspective in order to frame the challenging areas – as such, the first research question is descriptive in its approach. The second research question aims to describe and explain the relations between and among the challenges. This is achieved by, based on a limited selection of cases, indicating potential causal relations between and among the perceived challenges of the actors in focus, the CVM and hauliers, and as such, the second research question is explanatory in its approach.

### 3.2 Research process

Becoming an Industrial Ph.D. after 18 years of work within Scania and, thereby, the heavy-duty commercial vehicle industry entailed extensive possibilities: “...being allowed to be at the forefront and conduct research to understand the consequences for whole industries on how value will be created and captured, in novel ways, in the future is a powerful and challenging combination that encompasses my interest for marketing, product development, technological innovation as well as sustainable development. It will also allow me to synthesize many years of professional experience into an academic context which will make this journey even more interesting in many ways.” (Extract from my letter of application to the position as Industrial Ph.D.). This paragraph summarizes my vision and expectations in becoming an Industrial Ph.D.

This journey has entailed both pros and cons. For instance, it would be absurd not to acknowledge that the accumulated experience constitutes a strength in this journey – been there, done that – which has been of great help while exploring the challenges of implementing HBEVs in road freight transport. In addition, the access to key decision-makers with insights into technical, strategic and commercial aspects of electromobility from one of the largest CVM entailed a unique opportunity from a research point of view. However, I was not prepared for the challenging process of becoming a researcher in a familiar area, coming from a practitioner's perspective. The accumulated experience also brings downsides with it, e.g. the bias – preconceptions on how business is done, the role of CVM, what’s important for customers and so on – that is always present and can in many cases act as a blindfold. This has been a fact that I have had to admit, bear in mind and be reminded of during this incredible journey – a balancing act indeed.

The research process started with a systematic literature review aiming to explore how business model alignment between different supply chain actors was described and analysed in the context of supply chain management. Although the resulting conference paper is not included in this thesis, one of the findings of this review was the limited body of research on the connection between the transport provision chain and their suppliers, the automotive industry, i.e. the connection between the hauliers and the CVMs in this specific case. Understanding the interface between the hauliers and CVMs is crucial because it constitutes the arena where the implementation of HBEVs begins. Hauliers own or lease the trucks, and, as technology adopters, constitute the initial stage of the evaluation process when implementing new technology in road freight transport. The fact that this interface had not been thoroughly explored, and the necessity to understand the role the CVM, as technology providers, in relation to the hauliers, in the implementation process of HBEVs was the first step in the narrowing process of the research.
The research project is about future transport and logistics business models. A logic second step, after the initial systematic literature review, was to start searching, bury myself in literature on business models and business model innovation to realize that the field was broad and sprawling – a swamp, a labyrinth that would devour me – since business models can be studied, described and explained from different perspectives depending on the starting point of the research. I found myself at a crossroad as to whether to continue on the business models path or abandon it. A way out of this was to shift perspective and invert the question: *What is a business model?* to *Why do you have a business model? What is the outcome of a business model?* To me, the answer is to create and capture value. To be able to capture value, it needs to be created. One way of creating customer value is by solving problems or problem areas for customers through customer offers or value propositions. In order to do so, it is crucial to understand the problem or the problem area, the context and the need – in other words, it’s crucial to understand the challenges faced by customers in a specific context. In an electromobility context, the challenges of implementing HBEVs represent a source of value creation for CVMs and as such, it is important to identify the challenges, understand their nature as well as their interrelation. It has been a journey that had a strong focus on business models around electromobility and HBEV implementation from the CVM perspective, as a starting point, to a position where the actors’ perspective on the challenges of implementing HBEVs is in focus. Although value creation, value creation mechanisms and value propositions are areas of interest, that will be explored in the future; the challenges are the focus of this thesis. Consequently, the unit of analysis of the thesis is the challenges of implementing HBEVs in road freight transport from the perspective of CVMs and hauliers – as shown in Figure 3.

Due to the fact this subject had not been thoroughly explored and systematically described from the perspective of the CVMs and hauliers, some explorative interviews to identify and frame the challenging areas concerning the implementation of HBEVs were conducted. The interviews were carried out with key informants with different perspectives within Scania (senior vice president, project manager and product manager) and one haulier company (CEO) – all of them working strategically and operationally with implementation of electromobility in road freight. The outcome of the explorative interviews was a preliminary set of categories for the challenges of implementing HBEVs. The explorative interviews provided the researcher with valuable insights into the challenges, which helped frame the problems areas; but given the limited number of interviews, it was obvious that more interviews were needed to gain a deeper understanding of the challenges and their interrelation. The second step was to delineate and plan interviews with decision-makers within Scania and hauliers companies to bring as
many perspectives and gather as much information as possible about the challenges of implementing HBEVs in road freight. The explorative interviews were used as starting points and inspiration for study 1 and study 2.

This licentiate thesis is a compilation thesis based on two papers, a case report and the thesis frame. The papers and the case report are the result of case studies carried out at Scania and at a group of haulier companies in Sweden, the Netherlands and Italy. Semi-structured interviews had been carried out with decision-makers working with electromobility strategically, commercially and operationally within Scania and within the haulier companies. The different papers compiled in this thesis and how they are related to the research questions are presented in Table 2.

Table 2. Papers dealing with challenges of implementing GLPs

<table>
<thead>
<tr>
<th>Paper</th>
<th>Focus</th>
<th>RQ1</th>
<th>RQ2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper 1</td>
<td>Challenges of implementing HBEVs for CVM and hauliers from the CVM perspective</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Paper 2</td>
<td>Challenges of implementing HBEVs from the Haulier perspective</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Case Report</td>
<td>Scania’s perspective on challenges with electromobility and its commercialization</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

The research process and resulting papers are visualized in Figure 4. The dashed area in the figure corresponds to the systematic literature review, not included in this thesis and carried out at the start of the process, which contributed to confirm and further detail the absence of research on the relationship between the transport provision chain and their suppliers, the automotive industry. In this specific context of electromobility, the implementation of HBEVs, it means the absence of research into the relationship between the CVM and the hauliers. The studies include the processes of analysing and writing the papers and case report.
3.3 Research Design

Case study is the research design used during the research process consisting of study 1 and study 2. Within the scope of the two studies different methods have been used as sources of evidence (Yin, 2018).

3.3.1 Case Study

Case studies are one appropriate way to study a phenomenon to gain concrete, contextual and in-depth knowledge about a contemporary phenomenon that is unknown or unexplored, and allows the exploration of key characteristics and implications of the phenomenon in focus for the case study (Yin, 2018; Merriam, 1994). As electromobility is irrupting into the heavy-duty commercial vehicle segment with the implementation of HBEVs, there is a need to understand the challenges of implementing this new technology, not only from a technological point of view, but also from a managerial and business-related perspective. Study 1 aims to identify and classify the perceived challenges of implementing HBEVs from the CVM perspective, while Study 2 aims to incorporate into the thesis the hauliers’ perspective on the same subject. The appended papers and the case report in this thesis are all based on case studies aiming to shed light on the phenomenon in focus – the challenges of implementing HBEVs.

Another decision to be made when conducting case studies is whether to use a single or multiple-case research design, and the unit of analysis is decisive in the selection of the case study research design (Yin, 2018). Two different approaches were selected when designing the studies. For study 1, a single-case study design approach was selected, since the aim of the study was to identify the challenges of implementing HBEVs from a CVM-perspective. There are two CVMs in Sweden and both are large organisations. In order to capture the challenges from such a large organisation, an in-depth study needed to be conducted, and this requires accessibility and the possibility to conduct interviews at different points within a longer timeframe. Two rationales to choose a single-case study design are accessibility and longitudinally (Yin, 2018). Accessibility refers to the possibility to observe and analyse a phenomenon that is very difficult to access (ibid). Longitudinally refers to the possibility conduct a longitudinal case, i.e. being able to study the same single-case at different points over an elongated time period (ibid).

For study 2, a multiple-case study design approach was selected because the aim of the study was to identify the challenges of implementing HBEVs from the haulier’s perspective. The rationale for choosing a multiple-case study design was the diversity of haulier companies in terms of size and operations, and the necessity to capture different perspectives on the challenges. Thus, to achieve this, it was necessary to find different types of haulier companies to cover as many perspectives as possible. Moreover, multiple-case studies are considered more robust because findings in this type of case study are considered more compelling (Yin, 2018). According to Yin (2018), a multiple-case design approach should be used following a
replication logic, not a sampling logic. In line with this, the context as well as the unit of analysis are the same for each one of the companies in the study. The context is the implementation of HBEVs in road freight, and the unit of analysis is the challenges of implementing HBEVs in road freight.

Selection of Cases

It was obvious from the start of the research process that Scania would be the main case of study 1 due to my position as Industrial Ph.D., albeit there are underlying reasons that justify the choice. First, Scania is a good study object because the company has invested heavily in electrification. The company is an active actor in the transition to electromobility and has considerable insights into the challenges of implementing HBEVs. Second, accessibility (Yin, 2018) – the fact that I, as Scania employee, have access to the entire organization and to key individuals, working strategically and commercially with electromobility and the implementation of HBEVs. Finally, longitudinally (ibid) – the possibility to conduct a longitudinal case study within the company over a time period of 5 years. Thus, the longitudinal rationale of the study is not fulfilled in this thesis, but will be fulfilled to the doctoral thesis.

A unique opportunity to contrast preliminary results of the initial interviews carried out within Scania occurred, even though my position as Scania employee makes it very difficult to gain access to competitors. I had the possibility to visit the head office of a German competitor to conduct an interview on the subject in focus – the challenges of implementing HBEVs – with two Project Directors, deeply involved in the development and commercialization of HBEVs. Although, the interview confirmed that the overall perceived challenges were similar among the two CVMs, a more thoroughly study may have shed light to specific differences. Thus, this interview should be considered a validity check, not a case.

Study 2 aimed to identify the challenges of implementing HBEVs from the hauliers’ perspective. The haulier companies included in study 2 were chosen with electrification as the common denominator – the companies should have tried, ordered or actually being operating HBEVs. Another common denominator and important criterion when choosing the case companies, was the decision that all interviewees should be involved in the transition to electromobility and had some decision-making role at the selected companies – following a key informant and reputational sampling strategy according to Patton (2015). As stated before, a multiple-case study design was chosen because of the diversity of haulier companies in terms of size and operations, and the necessity to capture different perspectives on the challenges. Consequently, the selection criteria for the haulier companies in study 2 was based on a Maximum variation sampling strategy (Patton, 2015). The aim of this strategy is to capture and describe central themes and common patterns that cut across a great variation of study objects (ibid). In line with this, the companies chosen for study 2 differ in size and operations; and are based in Sweden, the Netherlands and Italy to add a geographical variation to the sample. More detailed information is to be found in Chapter 4.
3.4 Research methods

To achieve the purpose of this thesis different research methods has been used: semi-structured interviews, document studies and narrative literature reviews. According to Yin (2019), data collection for case studies can be carried out using various methods, for instance interviews, document scanning and direct observations. In addition, literature reviews are an important element of any research that helps the researcher to gain an understanding about the subject in focus (Bell et al., 2018). An overview of the methods used in study 1 and study 2 are visualised in Table 3.

Finally, the analysis methods in the thesis frame are presented at the end of this section.

<table>
<thead>
<tr>
<th>Study</th>
<th>Case Study Design</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Semi-structured Interview</td>
</tr>
<tr>
<td>Study 1</td>
<td>Single-case</td>
<td>X</td>
</tr>
<tr>
<td>Study 2</td>
<td>Multiple-case</td>
<td>X</td>
</tr>
</tbody>
</table>

3.4.1 Semi-structured Interviews

The appended papers, case description and the analysis in the thesis are mainly based on semi-structured interviews as a data collection method. A semi-structured interview is a data collection method that relies on asking questions in more general terms within a predetermined subject or area without having to follow the interview guide to the letter, i.e. while a few questions are predetermined, others aren’t planned but are a result of the interviewee’s answers and explanations and allow the researcher to gain insights based on the interviewee’s perspective (Bell et al., 2019).

Within the scope of study 1, a total of ten semi-structured interviews and two focus group interviews (Bell et al., 2019) were conducted. The semi-structured interviews were conducted within Scania at its head office and at the business units in Sweden and Italy. The focus group interviews were conducted at the business unit in the Netherlands and at the German competitor. The focus group interviews were conducted in similar way than a semi-structured interview, although with the participation of two interviewees. An overview of the interviewees’ position is presented in Table 4. An interview guide (see appendix I), consisting of five open-ended questions, was sent beforehand to the interviewees. The interviews were carried out in person or via Teams and lasted 45–75 minutes. The interviews were recorded in order to be transcribed and analysed afterwards (Bell et al., 2019). An exception to recording the interview occurred when the two Project Directors were interviewed. In this particular case, the researcher was not allowed to record the interview, but a memorandum was sent to the interviewees afterwards to...
check that the main ideas had been understood correctly. The transcriptions were sent to the interviewees for approval and to give the interviewees the opportunity to check that no misunderstandings had occurred.

The same approach was applied when conducting study 2. A total of eight semi-structured interviews were conducted in three different countries – Sweden, the Netherlands and Italy. An overview of the interviewees and their position is presented in Table 5. Similar to study 1, an interview guide consisting of five open-ended questions (see appendix II) were sent beforehand to the interviewees. The interviews were carried out in person or via Teams and lasted 45 – 75 minutes. The interviews were recorded in order to be transcribed and analysed afterwards (Bell et al, 2019). The transcriptions were sent to the interviewees in order for them to be approved and to give the interviewees the opportunity to check that no misunderstandings had occurred.
3.4.2 Document studies

According to Yin (2018), the most important role of documents is their corroborative and reinforcing effect on evidence from other sources. Within the scope of study 1, and thanks to my position as Scania employee, I’ve had the opportunity to access internal documentation concerning electromobility in the form of presentations, consultant reports, market analysis reports regarding strategies, challenges ahead, and customers attitude to electromobility. In addition, external information such as the company’s annual reports and webpages has been consulted as well. The external information was the main source of facts for the introductory company presentation in the appended case report.

Similarly, within the Scope of study 2, complementary information regarding the participating haulier companies has been collected through the scanning of the companies’ homepages to be included in the case descriptions presented in Chapter 4.

3.4.3 Narrative Literature review

Literature reviews are an important part of any research process. It allows the researcher to get acquainted with the subject in focus and provide an overview of the current knowledge in the research area (Bell et al., 2019). In this thesis, and throughout study 1 and study 2, narrative literature reviews has been conducted to structure the empirical findings and to contrast the findings with the existing literature. Narrative literature reviews allow the researcher to have a broader scope, an open-minded approach, when scanning and exploring an area of interest (ibid). For instance, using a snowballing approach to scan and explore adjacent literature based on the references of previously reviewed literature is a way to find complementary or relevant literature. The researcher has used a snowballing approach when searching relevant literature on the challenges of implementing electromobility in logistics contexts and challenges of implementing Green Logistics Practices (GLPs). In this process the database UniSearch, that links to several other databases such as Scopus and Business Source Premier, was used when performing the narrative literature reviews. From the beginning different combinations of keywords, search strings, were used to find relevant literature on the two areas of interest as recommended by Bell et al. (2019). The resulting primary literature was then reviewed, and interesting references were followed to examine if they could add new perspectives that could contribute to expand the results from the primary search.

3.4.4 Methods for the analysis in the thesis frame

Describing the challenges of implementing HBEVs

The analysis of research question 1, to described the challenges of implementing HBEVs, was performed by using the empirical findings of study 1 and study 2, and contributions from literature on challenges or barriers. In this thesis, the challenges of implementing HBEVs are described from the perspective of two group actors – the CVM and hauliers. Thus, the first step was to find a framework that encompassed the different perceived challenges of the CVM and
the hauliers and that could be used to structure and categorize the empirical findings from both studies. There were two streams of literature to take into consideration – challenges of implementing electromobility in road freight transports, and challenges of implementing GLPs. Given that both streams highlighted similar elements as challenges, a framework presenting the challenges of implementing GLPs from the perspective of the trucking industry, the hauliers, the technology adopters, was chosen as a point of departure. Consequently, the empirical findings of study 1 and study 2 were structured and categorized according to the framework presented by Jovanovic et al. (2020).

The second step, after having categorized the empirical findings, was to contrast these with the existing literature on challenges of implementing electromobility in road freight transports, and with the challenges of implementing GLPs, to find similarities or differences between the findings and the literature from the perspective of each category.

**Explaining the interrelation of the challenges**

The analysis of research question 2, explaining the interrelations between the challenges, was a two-fold process that had, mainly, contributions from the empirical findings. The first step was to identify interrelations between the perceived challenges of the CVM and the hauliers in each one of the categories from the framework used to answer research question 1. This was done by comparing the perceived challenges of the CVM with the perceived challenges of the hauliers, and identifying relationships between them. For instance, technology-related challenges for the CVM posed a technology-related challenge for the hauliers as well, e.g. limited battery capacity (a challenge for the CVM) entails a limitation in range (a challenge for the hauliers). In some cases the relationships could be perceived to be a reflection on of each other, that is to say, that the challenge of CVM became the challenge of the hauliers or vice versa.

The second step in the analysis was to identify interrelationships between and among the challenges in the different categories. The aim of the second step was to highlight the complexity that implementing HBEVs entails, and to highlight the reinforcing effect the challenges can have on each other, contributing in this manner to inhibiting the implementation of HBEVs even more. This was done by identifying and displaying potential cause-effect relationships between and among the perceived challenges of the CVM and hauliers. For instance, the limited battery capacity (technology challenge for the CVM) entails a limitation in range (technology challenge for the hauliers) that results in and loss of operational flexibility (organizational challenge for the hauliers), that ultimately have a negative impact on the haulier capacity to accept unplanned assignments (market challenge for the hauliers).

The reasoning behind choosing these two steps when answering Research Question 2 lies in the ambition to highlighting the intrinsic relationship between the CVM and hauliers as technology provider and technology adopter, and the ambition to highlight the complexity entailed by the challenges when observed as a whole.
3.5 Research quality

According to Yin (2018), the quality of research designs can be judged based on four tests—construct validity, internal validity, external validity, and reliability—and corresponding case study tactics. Based on Yin (2018), and inspired by Hellström and Olsson (2024), Table 6 gives an overview over the trustworthiness criteria of this thesis as well as the implemented measures.

Table 6. Trustworthiness criteria and implemented measures

<table>
<thead>
<tr>
<th>Test</th>
<th>Tactic</th>
<th>Implemented measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct validity</td>
<td>- Use multiple sources of evidence</td>
<td>- Used methods for data collection: semi-structured interviews, document study</td>
</tr>
<tr>
<td></td>
<td>- Engage key informants in relevant functions</td>
<td>- All interviews had a cross-functional overview and were carried out strategically,</td>
</tr>
<tr>
<td></td>
<td>- Have key informants review draft case study report</td>
<td>- connectively or operationally with the implementation team</td>
</tr>
<tr>
<td></td>
<td>- Do pattern matching</td>
<td>- The transcribed interviews were sent to the interviewees to secure that no understanding had occurred.</td>
</tr>
<tr>
<td>Internal validity</td>
<td>- Do explanations building</td>
<td>- Identified empirical data [the challenges] were contrasted to existing literature in the analysis,</td>
</tr>
<tr>
<td>(extent to which the study establishes a trustworthy causal relationship)</td>
<td>- Address rival explanations</td>
<td>- Explanation building based on the empirical results was applied to esposing RQ2.</td>
</tr>
<tr>
<td></td>
<td>- Use logic models</td>
<td>- No real explanations were considered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- No logic models were used</td>
</tr>
<tr>
<td>External validity</td>
<td>- Engage relevant actors</td>
<td>- A CVM is the study object of a single-case study. The empirical findings at the CVM were contrasted to results from an interview with a major competitor as a validity check.</td>
</tr>
<tr>
<td>(extent to which the study findings can be generalized)</td>
<td>- Use replication logic in multiple case studies</td>
<td>- Insurer companies with experience in implementing electromobility or NEV were the study objects in a multiple-case study.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The findings have been contrasted with previous research.</td>
</tr>
<tr>
<td>Reliability</td>
<td>- Maintain a chain of evidence</td>
<td>- A list of the participating companies and interviewees have been included.</td>
</tr>
<tr>
<td>(extent to which the study findings are consistent and repeatable)</td>
<td></td>
<td>- Standardized questionnaires have been used at the CVM and at the insurer companies.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- The interviews have been recorded and transcribed.</td>
</tr>
</tbody>
</table>
4. Case Descriptions

In the following chapter the case companies in Study 1 and Study 2 will be presented. A short presentation of the case company in Study1 is made, followed by presentations of the case companies in Study 2. An overview of the case companies of Study 2 is presented in Table 7.

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Position of interviewee</th>
<th>Operation Type</th>
<th>Number of Trucks</th>
<th>Number of BEVs</th>
<th>Turnover</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Sweden</td>
<td>Business Area Manager</td>
<td>Long Haul /Regional /Urban</td>
<td>100</td>
<td>1</td>
<td>1.1BSEK</td>
</tr>
<tr>
<td>B</td>
<td>Sweden</td>
<td>Owner/CEO</td>
<td>Long Haul /Regional /Urban</td>
<td>75</td>
<td>2</td>
<td>137MSEK</td>
</tr>
<tr>
<td>C</td>
<td>Sweden</td>
<td>Green Technology Lead</td>
<td>Long Haul /Regional /Urban</td>
<td></td>
<td></td>
<td>10.9BSEK</td>
</tr>
<tr>
<td>D</td>
<td>Sweden</td>
<td>Owner/CEO</td>
<td>Regional/Urban</td>
<td>160</td>
<td>5</td>
<td>120MSEK</td>
</tr>
<tr>
<td>E</td>
<td>Sweden</td>
<td>Technology Development Manager</td>
<td>Regional/Urban</td>
<td>250</td>
<td>3</td>
<td>1.73BSEK</td>
</tr>
<tr>
<td>F</td>
<td>Italy</td>
<td>Fleet manager</td>
<td>Long Haul /Regional /Urban</td>
<td>750</td>
<td>1</td>
<td>750MEuro</td>
</tr>
<tr>
<td>G</td>
<td>The Netherlands</td>
<td>CEO</td>
<td>Long Haul /Regional /Urban</td>
<td>250</td>
<td>None, but HEVs</td>
<td>70MEuro</td>
</tr>
<tr>
<td>H</td>
<td>Sweden</td>
<td>Logistics Strategy Director</td>
<td>Long Haul /Regional /Urban</td>
<td></td>
<td></td>
<td>90.6MSEK</td>
</tr>
</tbody>
</table>

Scania CV

Scania was established in 1891 and is today one of the world’s leading supplier of transport solutions for heavy trucks and busses. The company is the result of the merge of Vagnfabriks Aktiebolaget i Södertelje (Vabis) and Maskinfabriksaktiebolaget Scania in 1911. In 2014, Scania became a fully owned subsidiary of the Volkswagen Group and as from 2015, the company is a part of Volkswagen Truck & Bus GmbH, a company created to group the commercial vehicle brands – Scania, MAN and Volkswagen Caminhões e Ônibus – under one umbrella. In 2018, Volkswagen Truck & Bus GmbH became TRATON Group.

Scania has a global company with nearly 57,000 employees in more than 100 countries. The company has production units and research centres in Europe, South America and Asia as well as a sales and service network, consisting of captive and non-captive distributors or subsidiaries, strategically placed to meet customers’ needs.

A more comprehensive company description can be found in the appended case report.
Company A

Company A is based in Östergötland, Sweden, and is jointly owned by hauliers companies. The company operates as a joint ordering office for transport buyers. The company sell and book transport assignments, and pass them on to the available haulage company that performs the transport services. Distribution and planning of transport assignments takes place centrally, i.e. bookings are received and then these are planned on the trucks which are controlled entirely from the remote control office. The total turnover amounts to approximately 1.1 billion SEK during 2022.

The company has two business areas – Logistics, and Construction & Contracting. The logistics business area includes long-distance haulage, distribution of breakbulk cargo, biofuel haulage, environmental haulage services, warehousing and 3PL services and transport of sea container. The construction business area works mainly with shafts and trucks equipped with cranes and concrete mixers and pumps. On the logistics business area, the company works with larger customers and across larger areas, e.g. assignments where several haulage companies are involved, which means that they could not become transport suppliers individually. The logistics business operates around 100 trucks.

Regarding electrification, the company was the first company operating a HBEV in the region. The company has had the ambition to be early, be well-read and try to see the possibilities with the technology.

Company B

Company B is family-owned haulier company founded in 1937 and based in Östergötland, Sweden. The company’s operations include both logistics, warehousing and 3PL services. The haulage business covers all of Sweden, eastern Norway and also Europe on ad hoc transports. The company has a 15,000 square meter warehouse and currently has approximately 110 employees in Sweden and 5 in Norway. The company owns 75 trucks and 45 trailers. The total turnover amounts to approximately 137 million SEK during 2022.

The company became fossil-free 2015. Not a single new heavy diesel truck has been bought since 2018, but only biogas trucks. The company is used to invest in environmental friendly technology. Of the 75 trucks owned by the company 21 are powered from Liquid Biogas (LBG), 52 runs on HVO100 and 2 are HBEVs. In addition, the company has invested in solar cell panels to power the sections of the warehouse. Moreover, the company participates in a number of research projects on more energy-efficient driving as well as with Volvo in the development of aerodynamic vehicles.

Company C

Company C is a leading logistics and postal services company operating in the Nordic and Baltic regions. The company offers a range of services including postal and parcel delivery, logistics solutions, and e-commerce services. The company operates one of the largest postal and logistics networks in the Nordic and Baltic regions. The company turnover amounts to approximately 10,9 billion SEK.
In addition, the company is committed to sustainability, implementing initiatives to reduce carbon emissions and promote green logistics practices to minimize its environmental footprint. The company has been gradually incorporating Battery Electric Vehicles (BEVs) into its vehicle fleet for last-mile delivery and urban logistics. Moreover, the company has also joined several pilot projects and trials to test the feasibility and effectiveness of HBEVs in logistics operations and to assess their performance and charging infrastructure requirements. Furthermore, the company has invested in charging infrastructure at delivery depots, logistics hubs, and strategic locations to support the transition to electromobility in their operations. The number of HBEVs owned by the company today, could not be obtained.

Company D

Company D is a family-owned haulier company founded in 1957 and based in Skåne, Sweden. The company is part of the family-owned group consisting of the haulier company, a company that develops solar parks and one that develops charging parks. Company D operates as a subcontractor to DHL, performing transport assignments in urban and regional logistics operations. The goal is to replace as many conventional vehicles as possible with electrified vehicles. The company has approximately 250 employees and its fleet consist of 160 vehicles, both light and heavy trucks. The total turnover amounts to approximately 120 million SEK during 2022.

Moreover, the group owns Sweden's largest charging park for trucks with 22 charging points, with a potential to accommodate a further 18 charging points in the future, and is currently building a 1.5 hectare solar park. The company owns 5 HBEVs.

Company E

Company E is a municipality-owned based in Gothenburg. The company offers a range of environmental solutions to help businesses and municipalities achieve their sustainability goals. The company invests in innovation and technology to improve processes and to develop new sustainable solutions constantly. The company currently has and has for many years tested trucks with different fuel types to operate with the most environmentally friendly transport solution. In addition, the company has approximately 800 employees and 250 heavy vehicles in its fleet currently. All heavy trucks run on fossil-free fuel since 2015. The total turnover amounts to approximately 1.73 billion SEK during 2022.

In addition, the company has participated in various pilot projects and trials to test the feasibility of HBEVs in the company’s operations. The company has also invested in charging infrastructure to ease a transition to electromobility. The goal is for 30% of the entire fleet to be electrified by 2026. The company owns 3 HBEVs.
Company F

Company F is a family-owned Italian logistics company based in northern Italy. The company was founded in 1936 and is one of the most innovative and successful logistics companies in all of Europe. The company has 60 branches all over Europe and Asia. The company offers services in the following areas: full loads, partial loads and groupage, heavy and special transport, air and sea transports, logistics services and industrial relocations. The company has approximately 2250 employees and its fleet consists of 750 tractors and 1500 trailers. 95 percent of the fleet consists of Euro 6 engines, and as of 2021, the company has added 100 LNG to the fleet. The total turnover amounts to approximately 750 million euro during 2021.

One main aspect of the company’s culture is sustainability, and therefore, the company is investing a lot in sustainable transport solutions and believe that electrification is an important step or at least part of the sustainable transport solution of the future. The company started years ago to electrify part of the car fleet, and this year, started to operate the first electric truck together with a client in Milan. It’s one of the first HBEVs vehicles in Italy. In addition, the company believes that electrification is an important part of the future and want to be the one of the first movers operating this technology as transport solution. It's important to understand new technology, the new challenges in order to be able to use them in the best possible way. The company owns 1 HBEV.

Company G

Company G is a family-owned logistics service provider company based in The Netherlands. The company has more than 60 years of experience and offers dedicated transport, distribution and warehousing. The company operates from the Northeast Netherlands to anywhere in the Benelux. The company has approximately 500 employees and the fleet consist of 250 vehicles. The total turnover amounts to approximately 70 million euro.

Presently, the company has some Hybrid Electric Vehicles (HEVs) and are not considering to incorporate HBEVs. The company is waiting to see how the technology, the infrastructure and policy measures evolve before deciding to invest in HBEVs.

Company H

Company H is a transportation technology company focused on sustainability and innovation. The company was founded in 2016. The company offers Transportation as a Service solutions, allowing businesses to access transport services on a subscription or pay-per-use basis. The company also offers consulting services to businesses seeking to enhance the environmental performance of their logistics operations, as well as fleet management and optimization services to improve the efficiency of transport operations. The company collaborates with technology providers and logistics companies to accelerate the adoption of electric and autonomous vehicles. Although, the company is one of the largest buyer of HBEVs the number of HBEVs owned by the company could not be obtained.
5. Appended papers and report

In this chapter, summaries of the appended papers in this thesis are presented. In addition, the contribution of each one of the papers to the thesis is explained, as well as the author’s contribution.

5.1 Paper I – The Adoption of Battery Electric Vehicles - Challenges from the perspective of Commercial Vehicle Manufacturers.

Jorge Gutierrez Chiriboga and Maria Huge-Brodin (2022)
Conference paper presented at NOFOMA 2022 at University of Iceland in Reykjavik, Iceland.

5.1.1 Summary of paper I

This paper has its point of departure in the Commercial Vehicle Manufacture’s (CVM) perspective on the challenges of implementing Battery Electric Vehicles (BEVs). The CVM, as technology provider, is a key actor in the implementation BEVs in road freight transports. The transition to electromobility entails challenges for the CVM as well as the hauliers, as technology adopters. To facilitate the transition to this new technology, it is crucial to understand the challenges faced by these two important actors. The purpose of Paper I is to identify and classify the perceived challenges with electromobility for the CVM and hauliers, from the CMV’s point of view.

The paper is based on the preliminary results from study 1 that was being carried out at Scania, where semi-structured interviews were conducted with key decision-makers, working with electromobility both strategically and commercially. The preliminary findings indicated that the challenges could be classified as technological, operational and financial.

5.1.2 Contribution to the thesis

Paper I was the first step in classifying the challenges of implementing BEVs, and helped to identify and understand the perceived challenges from the CVM’s perspective. It also shed light on the challenges faced by the CVM as an organization when transitioning from ICE technology to electromobility. Paper I also helped to identify relevant literature on challenges for implementing environmental friendly practices in logistics contexts, as well as relevant literature on challenges of implementing electromobility in road freight transports.

5.1.3 Author’s contribution in Paper I

One of the authors organized and conducted the interviews, and the co-author participated on a number of them. The PhD student was responsible for the definition of the questionnaire and
the preparation of the interviews. When writing the paper, the introduction and the research design sections were written by the PhD student and Maria Huge-Brodin together. The PhD student was mainly responsible for writing the frame of reference, and the result and analysis chapters. Maria Huge-Brodin was mainly responsible for writing the discussion and conclusion sections. Both authors contributed with discussions and improvements to the whole paper.

5.2 Paper II – Implementing Electrified Road Freight – Challenges for Hauliers

Jorge Gutierrez Chiriboga, Maria Huge-Brodin and Uni Sallnäs (2023) – Work-in-Progress

5.2.1 Summary of paper II

Paper II has its point of departure in the hauliers’ perspective on the challenges of implementing HBEVs. The paper builds on a multiple-case study of eight hauliers – six from Sweden and one from Italy and the Netherlands respectively. The perceived challenges are classified into five categories: technology, finance, market, organization, and government. Furthermore, the challenges are explained through a theoretical lens based on Hardy (1996). From this perspective, the hauliers’ ability to implement HBEVs is explained by their power of resources, processes and meaning. The results indicate that large haulier companies, with financial resources and developed expertise are more prepared to implement HBEVs, and that close relationships with CVMs and with transport buyers are important elements for the hauliers ability to change. Conversely, system-related power counteracts the hauliers through the fast and unpredictable technology development pace, and misaligned and unstable policies around electrification of freight.

5.2.2 Contribution to the thesis

The contribution of Paper II to the thesis comes to large extent from the empirical data presented in the paper. Moreover, another contribution of the Paper II, is that it introduces the framework used to describe the challenges when answering RQ1.

5.2.3 Author’s contribution in Paper II

The PhD student was responsible for the definition of the questionnaire and the preparation of the interviews. The PhD student conducted all the interviews and in four of them, one supervisor participated. The PhD student was responsible for coding and analysing the empirical data. When writing the paper, the PhD student was mainly responsible for writing the section on empirical results, and all authors participated in the analysis and the discussions of the paper.
5.3 Case Report – Scania

Jorge Gutiérrez Chiriboga and (2023)

5.3.1 Summary of Case Report

The case report comprises an introductory presentation of Scania as a company, the underlying reasons for the company’s ongoing transformation and a presentation of the challenges of implementing HBEVs for Scania, as well as a description of the perceived challenges for hauliers companies from a Scania perspective.

The findings presented in this case report reflects, to a large extent, the challenges of implementing HBEVs from a sales perspective. This is the organisation within Scania meeting the customers that have embarked on the electrification journey. Furthermore, the findings indicate that the challenges of implementing HBEVs are of different nature, and are related to technology, finance, market, organization and policy.

The challenges presented in the report are of different nature and reflect how complex the transition to electromobility and the implementation of HBEVs are for Scania.

5.3.2 Contribution to the thesis

The main contribution of the case report to the thesis is the empirical data. It gives insights on different aspects on the challenges from the CVM’s perspective, and in relation to the framework used to describe the challenges when answering RQ 1. The empirical data also shed light on some of the interrelations between and among the challenges, which contributed to answering RQ 2.

5.3.3 Author’s contribution

Th PhD student has been responsible for the definition of the questionnaire and the reparation of the interviews. The PhD student conducted all the interviews and in three of them, one or two supervisors participated. The PhD student has been responsible for coding and analysing the transcribed interviews. The PhD student is the sole author of the case report.
6. Findings and analysis

In the following sections of this chapter the research questions will be answered by discussing and analyzing the findings in Study 1 and Study 2 using the chosen frame of reference based on) two literature streams – challenges of implementing GLPs in logistics contexts in general, and challenges of implementing electromobility – presented in Chapter 2 to achieve the purpose of this thesis.

6.1 How can the challenges of implementing HBEVs be described? Answering RQ1

The empirical findings in Study 1 and Study 2, show that the identified challenges of implementing Heavy-duty Battery Electric Vehicles (HBEVs) in road freight transports can be clustered and classified into the five categories proposed by Jovanovic et al. (2020) – technology, finance, market, organisation and government – in their study on challenges faced by the trucking sector, the hauliers, when implementing green initiatives.

6.1.1 Technology-related challenges

Commercial vehicle manufacturers

Findings from Study 1 show that the challenges of implementing HBEVs for the CVM, as technology providers, starts with the technology itself. Moving from the Internal Combustion Engine (ICE) technology to electromobility entails that the combustion engine, the heart of a conventional truck, is replaced by another component – the battery. Historically, the battery has not been a component developed by CVMs, but becomes the most important and valuable component when transitioning to electromobility. In this context, moving from ICE technology to electromobility is the major technological shift Scania has undertaken since the first truck was produced more than 120 years ago as stated by Vice President A at Scania: “We usually say that it’s a change as big as it was for Scania to go from a railway wagon manufacturer to a truck and bus manufacturer.”. This is in line with the work of Altenburg et al. (2016), where the necessity of mastering battery technology and coping with challenges connected to fundamental properties of batteries were highlighted as a major challenge ahead for incumbent companies in the automotive industry, among them CVMs, when transitioning from ICE technology to electromobility.

There are basic differences between electromobility and ICE technology, characteristics or properties connected to electromobility, and ultimately to HBEVs, that could be perceived as shortcomings, when compared to conventional trucks. Findings in Study 1 show that inherent properties of electromobility such as limitations in battery capacity and weight of batteries have a significant impact on range and payload, which are considered two of the most important product properties of trucks.
The battery capacity is a challenge. Findings in Study 1 show that range is an important product property of a truck. There is an intrinsic relationship between energy density, battery capacity and range. The energy density—the amount of energy that can be stored in a given system or substance—of a battery today is lower in comparison to diesel. Diesel has 15 times more energy density per kilogram than batteries today. This fundamental physical property affects the battery capacity—the amount of energy a battery can store—i.e., the higher the battery capacity, the higher the amount of energy stored in the battery. Consequently, the battery capacity has a direct impact on the range—defined as the distance an electric vehicle can operate before the battery needs to be recharged. The higher the battery capacity, the longer the range. In an electromobility context range becomes extremely important as a product property because range has a direct impact on how a HBEVs can be operated, as explained by Director D e-mobility: “...you can use a diesel tractor for everything, it has so much flexibility. There is never any limitation in what you can do with that truck. You can do almost everything with it, but all of a sudden there is a truck that can’t do everything and then you have to understand if things can actually be done in a different way...” Improving the energy density of batteries means improved battery capacity and, as a result, improved range for HBEVs. Thus, the battery capacity is a challenge. Similar results are found in literature on challenges of implementing Electric Freight Vehicles (EFVs) in city logistics (Melander et al., 2022) and battery electric trucks in urban operations (Hovi et al., 2020), where the limited range and reduced load-carrying capacity were highlighted as two of the main technology-related challenges of implementing electromobility in road freight transports.

The weight of the batteries is a challenge. Findings in Study 1 indicate that another important product property of trucks is the load-carrying capacity. The weight of the batteries reduces the load-carrying capacity, the payload, of HBEVs. Payload is the maximum amount of weight you can safely load to a truck. Batteries add 600 kilos approximately, reducing the load-carrying capacity with the same amount of weight: “It is a heavy component. Adding a component that weighs much more will reduce the load capacity.” (Senior Vice President A). Reduced load-carrying capacity, due to the weight of the batteries, affects the amount of freight it is possible to transport. This has a negative impact on the hauliers’ profitability because reduced load-carrying capacity results in less earnings for the transport operator, as explained by Director A e-mobility: “There we may have an initial challenge, that batteries are heavy and that the entire income statement is affected by how many pallets you can transport. Can you transport 32 or 33 pallets? Depending on how much you get paid per pallet unit or on how you are being paid, it entails that losing a pallet in load-carrying capacity over 8 years hits quite a lot if you accumulate the potential loss of revenue.” Thus, the weight of the batteries is a challenge. Likewise, similar results are found in literature on challenges of implementing (EFV) in city logistics (Melander et al., 2022), and on battery electric trucks in urban operations (Hovi et al., 2020), where reduced load-carrying capacity was highlighted as an important challenge in implementing electromobility in road freight transports.

The lack of infrastructure is a challenge. Findings from Study 1 show that infrastructure, or rather the lack of it, is considered to be one of the main technology-related challenges to a successful implementation of HBEVs. The fact that a completely new infrastructure system has to be developed and needs to be in place to be able to operate HBEVs on a large scale is a challenge, as described by Director C e-mobility: “The infrastructure and accessibility, meaning enough public chargers at strategic transport corridors but also grid capacity. Without that it won’t work no matter how good you are.” This is in line with literature on
challenges of electromobility in general (Biresselioglu et al., 2018) and on challenges of implementing EFV in city logistics (Melander et al., 2022) that highlight the lack of charging infrastructure as a main challenge inhibiting the transition to electromobility and electrified freights.

While CVMs have the potential to influence and improve, to some degree, the energy density and the weight of batteries, the infrastructure is beyond control due to its complexity and the fact that it requires the engagement of different actors from other sectors of society – authorities, grid owners, electricity providers, charging equipment providers, land owners, facility owners, among others; “The infrastructure. It feels more and more every day that there is the lead time to get it in place... we can notice that in various European countries it will go faster, in other countries it will be a very long process. It will be a huge challenge to electrify large parts of the vehicle fleets” (Director A, e-mobility). Thus, the lack of infrastructure is a challenge for the CVMs.

Hauliers

From the hauliers’ perspective, implementing HBEVs entails several challenges as well. The limited range is a challenge. Findings in Study 2 show that hauliers perceive the limited range of HBEVs as a challenge. Although similar results have been presented, for instance, by Anderhöftstadt and Spindler (2019); Melander et al. (2022), their focus have not been on HBEVs, but light trucks (above 12 tonnes) and EFV respectively. Moreover, the limited range of HBEVs entails that the truck is not as flexible as a conventional truck, as stated by Business Area Manager, Company A: “We have some limitations, whether it’s the range or the need to stop to charge; we can’t do just anything.”.

The load-carrying capacity is a challenge. Findings from Study 2 also indicate that the load-carrying capacity of HBEVs is considered a challenge. Range is tightly related to battery capacity. A way of improving range is adding the number of batteries carried on the HBEVs – the more batteries, the longer the range. However, the weight of the batteries is a limiting factor because it has a direct impact on the load-carrying capacity of the trucks and needs to be taken into account, as explained by the Fleet Manager in company G: “Another big challenge is the trade-off between payload and the weight of the battery.” Reduced payload means that less cargo can be freighted, resulting in reduced earning capacity for the hauliers. Therefore, the load-carrying capacity of HBEVs is also a challenge for hauliers when implementing HBEVs. Similar results have been highlighted by Quak et al.(2016) and Melander et al. (2022), although they focused on EFVs in city logistics.

The lack of infrastructure is a challenge. Findings from Study 2 indicate that the lack of infrastructure – public charging points along the roads and sufficient grid capacity to power these charging points – is also considered to be one of the main challenges and a determinant factor for the implementation of HBEVs, as stated by the CEO of Company B: “The charging infrastructure is the biggest stumbling block today.” While the CEO of Company H said: “The bottleneck of the speed of transformation is the development of the grid.” Literature on the challenges of implementation of electromobility as a technology (see, for example, Biresselioglu et al., 2018), and literature on challenges of implementing electrified freight transports, for example Quak et al. (2016), Dong et al. (2018), Hovi et al. (2020) and Melander
et al. (2022), point out the lack of infrastructure as a major challenge inhibiting the transition to electromobility. A conclusion from this congruency in literature is that it shows that electromobility entails the need for deploying a totally new infrastructure system regardless the type of electric vehicle – eLCV, EFV, HBEV – for it to become a viable path to decarbonize logistics operations. However, what is also clear is the complexity of deploying new infrastructure. Thus, the lack of infrastructure is a challenge for hauliers when implementing HBEVs.

Finally, the development pace of the technology is a challenge. The pace of technology development – battery and charging equipment – is a source of uncertainty for the hauliers because the rapidness in its development and the novelty of the technology entails that it could become quickly outdated, as explained by the CEO of Company H: “Technology runs on high speed. You buy today’s technology to use it for three, four, five years, but within six months you have better technology which, you then need. That’s not where I want to invest my money.” Moreover, aspects such as the uncertainty concerning degradation of batteries, and the uncertainty concerning depreciation of HBEVs, which will be discussed in later sections, contribute to stress the perceived differences between battery generations and how they inhibit even more the implementation of electrified freight transports. Similar results have been presented in existing literature on challenges of implementing electromobility in different contexts: e.g. Quak et al. (2016) for EFVs in city logistics, and Imre et al. (2021) for EFVs in urban freight transport and city logistics in Turkey.

From a green logistics perspective, complexity and compatibility of technology is a factor influencing the implementation of environmentally friendly practices in logistics systems (Lin and Ho, 2011; Ho and Lin, 2012), and as such, it is an important aspect to reflect on. For the hauliers, implementing electromobility entails implementing a complex and less compatible technology. Complexity derives from the fact that purchasing a HBEV is not “business as usual” for the hauliers. It entails the implementation of novel, “unknown” technology that requires additional investments, i.e. higher costs and additional risks. In terms of compatibility, implementing HBEVs implies a loss of flexibility for the hauliers, mostly due to the limited range of the trucks and the lack of charging infrastructure, and requires a totally different setup from an operational point of view when it comes to route planning, for instance. This will be discussed in later sections in this chapter.

Summary

The main perceived technology-related challenges for the CVM and hauliers are summarized in Figure 5. For the CVM, the challenges are the battery capacity, the battery weight and the lack of infrastructure. For the hauliers, the challenges are the range, the load-carrying capacity, the lack of charging infrastructure, and the development pace of the technology. Moreover, findings from Study 1 suggest that there is an understanding of the hauliers’ challenges, when implementing HBEVs, from the CVM. Furthermore, findings in Study 1 and Study 2 indicate that, even though the challenges are not the same, there is a concordance between the perceived challenges seen from both the CVM and the hauliers’ perspective, which will be discussed when answering RQ2.
6.1.2 Finance-related challenges

Commercial vehicle manufacturers

Findings in Study 1 show that the complexity in finding suitable business models with appropriate financial solutions is a challenge for the CVM. The finance-related challenges of implementing HBEVs for the CVM are mostly related to the high market price of HBEVs and the novelty of the truck on the market. The high market price of HBEVs, two to three times higher than the price of a conventional truck, means that traditional financing models may entail higher financial risk for the CVM. Moreover, the novelty of the HBEVs on the market, and thereby, the absence of a second-life market, make it difficult to calculate accurate residual values for the HBEVs, i.e. the trucks estimated value at the end of their lease term or useful life. This further accentuates the perceived financial risks.

Traditionally, trucks are purchased or leased by the hauliers, but in the context of electromobility, with the higher market price, the novelty of HBEVs and the rapidness of the development in battery technology, hauliers are uncertain on whether invest or to wait, whether to buy or to lease. In many cases, they certainly do not want to buy the trucks and that inhibits the implementation of HBEVs in road freight transports. There is a need for financial solutions that help de-risk the investment for the hauliers and thereby, facilitate the implementation of HBEVs. However, de-risking the investment for the hauliers entails that risk must be transferred to other actors. For the CVM, de-risking the investment for the haulier is a plausible solution but implies having to increase their leasing portfolio and, thereby, add risk to the balance sheet and the exposure to financial markets as explained by Executive Vice President at Scania: “…if we play with the idea that the product cost of a battery electric truck is roughly twice that of a conventional truck, the balance sheet of our finance companies will be twice as large. A twice-as-large balance sheet for a finance company means twice as much risk, and if the customer doesn’t pay, we are left with the residual value. If many customers don’t pay, the probability is high that there is no functioning second-life market, and then we are left with a huge value that we have to write-off.”

The high market price of HBEVs in combination with the uncertainty concerning the residual value of the trucks, calls for new financing models. There are lots of financial aspects that need to be considered, and the business models need to be tested and assessed to find the best way
forward. Thus, the complexity in finding suitable business models with appropriate financial solutions is a challenge.

**Hauliers**

Findings in Study 2 show that the high initial investment in the truck and the required infrastructure is a challenge for the hauliers. The investments for implementing HBEVs, due to the high market price of the trucks, constitute a financial challenge and a major inhibitor to the implementation of HBEVs for the hauliers. Higher Capital Expenditures (CapEx) mean longer pay-off time and higher monthly costs: “It’s an expensive investment with a much higher monthly depreciation... It’s quite a tough investment in terms of liquidity.” (Business Area Manager, Company A). Similar results are presented in literature on challenges of implementing electromobility in different contexts: Quak et al. (2016) for EFVs in city logistics, Imre et al. (2021) for EFVs in urban freight transport and city logistics in Turkey, and Melander et al. (2022) for EFVs in city logistics in Stockholm. In addition to the higher market price of HBEVs, and the cost of investing in the required charging infrastructure, which in some cases implies upgrading the grid capacity around a facility, accentuate even more the challenging financial aspects of investing in HBEVs. The cost of the infrastructure has been highlighted as a challenge by Melander et al. (2022) in the context of EFVs in city logistics.

Interestingly, there is concordance between the literature on challenges of implementing electromobility and electrified road freight, and the literature on challenges of implementing environmentally friendly practices in logistics contexts: the literature streams highlight financial constraints as a challenge. For instance, Rossi et al. (2013), Evangelista (2014) and Perotti et al. (2015), highlight high investment costs as a major challenge when carrying on projects to implement Green Logistics Practices (GLPs). In the context of electromobility, considered in this case to be a GLP aiming to implement greener vehicle technology, it is not plausible, for a majority of the haulier companies, to invest in HBEVs due to lack of financial resources. The transport industry is characterized as highly competitive, with a focus on price cost efficiency and low margins (Oberhofer and Dieplinger, 2014; Evangelista, 2017; Takman and Andersson-Sköld, 2021).

Other findings in Study 2 show that uncertainty regarding the residual value of HBEVs is a challenge. The residual value (resale value) is an important financial parameter for the hauliers when evaluating investing in trucks. The fact that HBEVs have not been on the market very long, in combination with the uncertainty regarding the batteries life-length, and the lack of a second-life market, contributes to increase the uncertainty around implementing HBEVs: “With the electric vehicles, it’s difficult to calculate a residual value because it’s a new technology; otherwise, the hauliers usually have a good idea.” (Business Area Manager, Company A). Similar results have been presented in literature on challenges of implementing electromobility in different contexts: Dong et al. (2018) for EFVs in urban logistics, Anderhofstadt and Spindler (2019) for battery electric trucks above 12 tonnes; Tsakalidis et al. (2020) for eLCVs.

Moreover, additional findings in Study 2 show that the TCO of HBEVs is a challenge. For the hauliers, it is crucial to choose the correct truck to perform the transports assignments at the lowest possible cost. Implementing HBEVs entails that another important financial parameter – the Total Cost of Ownership (TCO) – is impacted negatively due to the higher monthly
depreciation and the uncertainty regarding the residual value. TCO is the lifetime cost of owning the truck and helps to compare and understand each vehicle’s financial performance.

A way of improving the TCO, to offset the negative effect of the higher monthly depreciation, is to increase the utilization rate, the mileage per day of the truck, due to lower operational costs (electricity cost, repair and maintenance costs). This means that the more kilometres the trucks operate daily, the better the TCO: *"You have to drive many kilometres to be profitable or cost-neutral."* (Business Area Manager, Company A). Similar results have been presented by Dong et al. (2018) for EFVs in urban logistics, and by Hovi et al. (2020) for BE-trucks in Norway. However, increasing the utilization rate is not easy. The actual range of HBEVs today is limited by the battery capacity and the lack of infrastructure. In practice, HBEVs are less flexible than conventional trucks today and cannot be used in all types of transport assignments, as highlighted in the literature on challenges of implementing electromobility (see, for example, Dong et al. (2018), Melander et al. (2022), Netzer et al. (2022)). Current generations of HBEVs are suitable to be operated in urban or regional assignments, meaning that the trucks are operated in the daytime in most of the cases, with a lower daily mileage as a result, as explained by CEO of Company B: *"We could change 60 per cent of our fleet to battery electric, but we have a difficult economic nut to crack when we talk about distribution traffic. All vehicles could run on electricity today, but they are such expensive vehicles, and the city vehicles maybe drive 30 or 40 kilometres a day."*.

Summary

The main perceived finance-related challenges of implementing HBEVs are summarized in Figure 6. From the CVM perspective, the main challenges are finding suitable business models with appropriate financial solutions to deal with the high market price of HBEVs and the uncertain residual value. From the hauliers’ perspective, the challenges are the high initial investments in the truck and required infrastructure, the uncertainty regarding the residual value of HBEVs, and the (TCO).

Once more, the challenges on both sides in the figure below denote an inherent relation between the challenges of the CVM and those of the hauliers. The challenge of the CVM is a reflection, of the challenges of the hauliers, and vice-versa, e.g. the high initial investments of the hauliers pose the challenge of developing suitable business models with appropriate financial solutions for the CVM. The interrelatedness of the challenges will be discussed in RQ2.

![Figure 6. Finance-related challenges](image-url)
6.1.3 Market-related challenges

Commercial vehicle manufacturers

Price has both a financial and a market dimension. For the hauliers, the market price of HBEVs becomes a challenge from an investment allocation perspective, a financial decision to me be made. For the CVM, the market price influences the hauliers’ willingness to pay for HBEVs. Thus, the market price of HBEVs is a also challenge from a market perspective. Findings in Study 1 show that the high cost of the batteries’ cells – the basic component of the batteries – means that batteries are expensive and are projected to account for approximately 50 per cent of the cost of the HBEVs: “The battery is now an important component that has extremely high value for the cost of each unit” (Director A e-mobility, Scania CV). Consequently, the cost of the batteries impacts the market price of the HBEVs negatively in comparison to conventional trucks, as stated by Manager, Scania Sweden: “There are large investments connected to an electric vehicle compared to a diesel vehicle. These trucks cost about two to three times more, which makes it very challenging for our customers to get into this.”. Although the price level of HBEVs is expected to decrease in the future, there will be a considerable price difference between HBEVs and conventional trucks. The high market price is often highlighted in existing literature on challenges of implementing electromobility in logistics contexts, although from the hauliers’ perspective: see for instance Quak et al. (2016) for EFVs in city logistics, Imre et al. (2021) for EFVs in urban freight transport and city logistics in Turkey, and Melander et al. (2022) in the context of EFVs in city logistics in Stockholm. Findings in Study 1 shed light on the challenge from the CVM perspective, where elements such as the novelty of the technology and the lack of economies of scale are two of the main reasons behind the price difference between the two types of trucks.

The residual value of HBEVs is a challenge. Other findings in Study 1 show that another important market-related challenge for the CVM is the uncertainty concerning the residual value of HBEVs. The main reasons behind this challenge relate to the impossibility of accurately calculating values. This is due to the absence of a second-life market for HBEVs because of the novelty of this type of truck in the market, lack of data on performance and degradation of batteries in different applications due to the low amount of HBEVs in the market, and the rapidness of the development in battery technology. New generations of batteries, with higher performance, are introduced every two or three years leading to a perception of previous generations of batteries being outdated. Calculations are based on theoretical expectations and entail a market-related challenge, but also a financial risk, as stated by Manager in Scania Sweden: “The big risk is really about the residual value because there is no second-life market for these products yet, and you don’t really know how long these batteries last.”. Although the residual value has been highlighted as a challenge for the hauliers in the existing literature (see, for instance, Dong et al. (2018), Anderhofstad and Spindler (2019), and Tsakalidis et al. (2020)), findings in Study 1 suggest that it also represents a market-related challenge as well as a financial risk for the CVM. It is a market-related challenge when facing the customers because it is an important financial parameter for the hauliers when choosing a type of truck, and it becomes a financial risk internally, due to the uncertainty connected to it.

Electromobility represent a challenge from a product portfolio point of view. Findings in Study 1 indicate that the development of an equivalent product portfolio of HBEVs, relative to the
existing product portfolio of conventional diesel trucks is a challenge. Scania’s conventional product portfolio consists of 36 applications for different purposes in urban, regional, long distance and off-road operations across different industries. Currently, the product portfolio of HBEVs is limited partly because of the available battery solutions – that limit the range of HBEVs – and partly because of the narrow available specifications. The challenge lies in the fact that only a limited segment of customers can be approached to discuss electromobility and this inhibits the implementation of HBEVs, as explained by Manager B at Scania Netherlands: “When contacting a customer and talking about his needs, application and vehicle solution-wise, right now we are not able to offer a broad scope of specifications. That’s one of the challenges.” Notably, similar results has been presented in the literature on challenges of implementing electromobility in logistics contexts although from the hauliers’ perspective: see, for instance, Quak et al. (2016) for EFVs in city logistics, and Melander et al. (2022) for EFVs in city logistics in Stockholm. This indicate a concordance between both perspectives – those of the CMV and hauliers – on the subject.

The aftermarket is a challenge. Findings in Study 1 show that the short and mid-term the aftermarket is a challenge due to the lack of reliable repair and maintenance contracts and warranty issues, and the need to upgrade the service network to be able to serve and maintain the HBEVs. First, defining repair and maintenance contracts and warranty issues is a challenge due to the limited number of outcomes from real cases regarding durability and degradation of the battery, which adds a huge amount of uncertainty: “...when we are defining a repair and maintenance contract today, we define on the same basis as diesel because we don’t know. We have an idea of how it will turn out...There are so many uncertainties in the battery, and every two years there is a completely new generation with completely different chemistry. We don’t have time to learn...Theoretically we know, but we are aware that we are not even close in understanding all the behaviours that a customer and a vehicle will have. So, there is a lot of uncertainty...” (Senior Vice President B, Scania CV). Second, implementing HBEVs implies that the service network needs to be upgraded to be able to serve and maintain this new type of truck. Equipment needs to be installed and mechanics need to be trained, which means huge capital investments and loss of service and workshop hours for the conventional aftermarket business.

Moreover, other findings in Study 1 regarding aftermarket issues indicate that, long-term, the implementation of HBEVs might have a direct impact on this traditionally profitable part of the business. Conventional trucks consist of many parts and components that need to be repaired and maintained, which is not the case with HBEVs. Removing the conventional driveline entails that less parts need to be changed or maintained, i.e. less parts and workshop hours will be sold. Similar results are presented by Dombrowski and Engel (2014), although with a focus on the impact of electromobility on small- and medium-sized car repair shops, and by Tongur and Engwall (2014) when studying the impact of introducing Electric Road Systems as an alternative to conventional trucks. Interestingly, a key element when offering HBEVs to customers – the reduced repair and maintenance costs – might become a major challenge for CVMs long-term with increased sales volumes of HBEVs. How large the impact – the potential earning loss – will be depends on the capacity of CVMs to replace the traditional repair and maintenance model with innovate service packages that are more in line with future customer needs from hauliers operating HBEVs.
Hauliers

The haulier companies’ market is the transport market, and is constituted by the transport buyers. Consequently, the market-related challenges for the hauliers are to be found in this market.

The commitment and support of the transport buyers from the start is a challenge. Having the customer, the transport buyer, on board when implementing HBEVs is a challenge. Findings in Study 2 show the crucial role the transport buyer plays for the haulier. The haulier needs the customer to be involved throughout the whole implementation process to understand the challenges and risks connected to electromobility and HBEVs: "Another challenge is the involvement of the client; they have to understand that it’s a new technology, that it’s a new market. The customer needs to be aware of the challenges of implementing infrastructure, charging infrastructure, and that we don’t know how the batteries really behave. It’s important that the client understands that something might go wrong. It’s not like a conventional truck if something goes wrong, and the risk is even higher with electrification." (Fleet Manager, Company G). The literature on challenges of implementing GLPs, highlights that the lack of customers’ environmental awareness, is a challenge for haulier companies trying to implement environmentally friendly practices: see, for instance, Perotti et al. (2015), Evangelista (2017) and Jovanovic et al. (2020).

Securing longer contracts and a high utilization rate are challenges. Findings in Study 2 show that the high initial investments when implementing HBEVs, with all the additional costs this entails, imply that hauliers need to secure income streams for a longer period to fulfil all financial commitments connected to the investments. Currently, hauliers wanting to invest in HBEVs need to find a transport buyer willing to sign up for a longer period of time, which represent a challenge as explained by Business Area Manager, Company A: “Getting the customer to sign up for a longer contract is a challenge. You also need a customer where the vehicle can run 100 per cent.” The need of a high utilization rate to offset the high initial investments has been presented in previous studies: see, for instance, Dong et al. (2018) for EFVs in city logistics, and Hovi et al. (2019) for Battery Electric trucks in Norway. Conversely, the literature on challenges of implementing GLPs highlights the inhibiting effect of a mismatch in expected contractual periods between the transport buyers and the hauliers: see for instance Kaciou-Maurin et al. (2015) and Jazairy (2020).

Getting higher fees for greener transports is a challenge. Findings in Study 2 show that the hauliers are faced with the challenge of transport buyers not willing to pay higher fees for greener transports, an opinion that was confirmed by the majority of the haulier companies participating in the study: “Transport buyers are not willing to pay for greener transports” (Fleet Manager, Company G). “A huge interest but no one wants to take costs for it.” (Technology Lead Manager, Company C). “Transport buyers want every advantage, but not every advantage has an positive cost effect... They never want to pay.” (CEO, Company H). “One wishes that more people were prepared to pay for environmentally friendly transport. There is a lot of talk, but in the end it’s the money that rules.” (CEO Company D). This challenge has been highlighted by Quak et al. (2016) and Dong et al. (2018) for EFVs in city logistics contexts, as well as Takman and Andersson-Sköld (2021) in a study with a focus on biogas-driven transports. Likewise, literature on green logistics often highlight the difficulties
faced by logistics companies to get paid for implementing GLPs: see, for instance, Abassi and Nilsson (2016), Bask et al. (2018) and Jazairy (2020).

**Summary**

A reflection regarding the market-related challenges of implementing electromobility, before summarizing them, is the fact that the market-related challenges of CVMs are different from the market-related challenges of hauliers. The explanation for that lies in the fact that "the market" for each one of these two actors is not the same. The market for the CVMs—the market for HBEVs—lies in the interface between CVMs and the transport networks, while the market for haulier companies—the transport market—lies in the interface between the freight flow and the transport network, as described in Figure 7. The market-related challenges of CVMs are connected to financial or operational aspects of the hauliers, while market-related challenges of hauliers are connected to financial or operational aspects of the transport buyers. Interestingly, the market-related challenges of the haulier companies are dependent on the commitment of a third party—the transport buyers—not the CVMs.

The main perceived market-related challenges of implementing HBEVs are summarized in Figure 8. From the CVM perspective, the main challenges are the high market price of HBEVs, the uncertainty regarding the residual value of HBEVs, not having an equivalent product portfolio for HBEVs as the conventional product portfolio for diesel trucks, as well as the need to delineate and develop the emerging aftermarket business. From the hauliers’ perspective, the market-related challenges are getting the support and commitment of the transport buyer from the start, securing longer contracts and a high utilization rate, and getting higher fees for greener transports.
6.1.4 Organization-related challenges

Commercial vehicle manufacturers

Electromobility entails several organizational challenges related to operations and culture throughout the entire organization of a CVM – research and development, purchase, production, and sales. However, the sales function is, in most of the cases, the interface, the point of contact, between the CVM and the haulier companies. From a sales perspective, the CVM is facing several challenges.

Selling HBEVs for the first time is resource-intensive and time-consuming – that’s a challenge. The need for informing and explaining about a totally new technology requires meeting the customers several times, without having the assurance of closing a deal, as explained by Manager e-mobility at ItalScania: “Meetings with the customers can be held 5, 10 times and maybe the customers give up because of the price, because the final customer doesn’t want to invest, because the TCO is not OK – it’s hard, it’s really hard.” In an electromobility context, selling a HBEV means guiding the customers into a transition to a new technology, not only selling the truck. The sales process involved with HBEVs becomes more consultative in nature compared to selling a conventional truck. This means that Scania needs to have an understanding about the hauliers’ operations in order to guide them regarding the most suitable truck solution and the required investments in charging infrastructure. In practice, this means that Scania needs to understand how they have driven the trucks historically, how far they drive and what their customers’ set-ups are, when and where they take breaks, how long it takes to load and unload, and if it’s possible to charge when the truck is at a standstill, as explained by Director A, e-mobility: “The key for us is to understand how to run the logistics, start at the top level and then understand what are the pain points in their existing set-ups that are affected when switching to electric.” This is not accomplished without the collaboration between different departments within the company, as stated by Senior Vice President A: “Selling an electric truck is not like selling a truck in the usual sense, but you have to have a team working together... it becomes much more important to be able to help the customer analyze their fleets. Customers don’t know what it means to buy an electric truck because there is so much more with the charging, how to solve it at the depo and how to keep track of how far you can drive.”

Moreover, the fact that an equivalent product portfolio for HBEVs is not in place requires that potential HBEV-customers need to be identified before they can be approached by the salesforce, and that is time-consuming, as explained by Senior Vice President B: “As a Scania salesperson today, you are used to selling the best product at the highest price; you are used to being premium. The customers almost come and knock on the door... you have to go from that to having to look for customers who are prepared to buy what you can offer. Because when we electrify, there will be a very narrow specification in the beginning.”

The need for having a high level of knowledge and a holistic approach is a challenge. Findings in Study 1 indicate that, unlike a conventional truck, HBEVs are dependent on the existence of charging infrastructure to be operational. This requires the salesforce to have a high level of knowledge, to deal with the complexity that electromobility entails, and to have a holistic approach to understand how the different parts – charging equipment, grid capacity and logistics operations – are related, and that is a challenge, as explained by Director B e-mobility: “... a
BEV can’t stand by itself. It needs a charger, charging infrastructure – the system gets bigger right away. You have to know: should I sell the charger? Does anyone else sell the charger? Is it the haulage company that wants a charger? Or is it the transport buyer who should have a charger? So, who is the customer then? You have a much more complex system to put together.”

The shift from product to complete solutions is a challenge. Findings in Study 1 indicate that complete solutions need to be in place when selling and implementing HBEVs for the first time. It is the decisive factor when hauliers choose the brand of their first HBEV, and that is a challenge, as explained by Senior Vice President B: “If you don’t solve the whole, then you won’t get the deal… System solution is absolutely decisive in this sale.” However, solving the whole in an electromobility context requires a shift in focus – from the truck, as the main component in an offering, complemented with services, to a customer-centric approach where the truck is only a part of a complete solution, with the customer’s need in the centre, as illustrated in Figure 9. In practice, a change of mentality is required, as described by Director D: “We are not a vehicle manufacturer. Many here perceive Scania as a vehicle manufacturer. As long as we perceive ourselves as one, we will never succeed. We are a system supplier of electrical solutions that meet the customer’s needs, and have a holistic view of it.”. This journey is one of the main challenges for Scania.

The learning process is a challenge. Other findings in Study 1 indicate that the consultative approach when selling the new technology is also the starting point of a learning process for Scania as an organization: “We are used to optimizing a vehicle, but now we have to optimize a transport or help how to set up a logistics system to better suit the new conditions, and we are not experts at that…” (Director D, e-mobility). An effective way of building knowledge and understanding hauliers’ operations more deeply is through pilot projects with customers to understand what solutions are needed in each customer segment, each application, to achieve the right cost level, investment level and uptime, as described by Director A, e-mobility: “This is how we work analytically. If we are going to speak consultatively with a customer, we go through their fleet, we look at where they have their accounts, where they operate, we look at the vehicle movements… if it doesn’t seem to be a problem we start a pilot project – we can learn together with them and afterwards we scale up. That is the natural process that we see.”
Moreover, pilot projects enable the testing of HBEVs in real conditions and allow data collection from real-world scenarios when time-to-market is crucial, which is important due to the rapidness of the development in battery technology: “Now it goes a bit faster and we want to test technology... We intend to do that through small series (pilot projects), getting products out, testing, learning from customers.” (Senior Vice President A). This type of advanced learning mechanism is referred to in existing literature as market experiments and explorative partnerships (Aggeri et al., 2009).

Furthermore, the challenges connected to the learning process are of an organizational nature: maintaining focus and having enough energy to drive change in this new context, incorporating new competences to cope with the complexity of electromobility, finding a way of working with customers, adding resources, developing adequate systems support, and managing knowledge building and knowledge transfer across the company from head office to business units and vice versa, as explained by Director D, e-mobility: “For us, the challenges are to set a different way of working with the customer. Set up an organization that can face the customer... After all, it’s about relationships: how to respond, how to ask, how to find the values. A lot of what we talk about in customer experience lies in really understanding the entire customer’s business and then work with it.”

The organizational culture is a challenge. Scania is a company with a long history, proud of its technological achievements during more than 120 years and a strong corporate culture. The company’s culture has always been highlighted as one of Scania’s most important strengths and one the reasons for the organizations success. Findings in Study 1 show that “Driving the shift” has presented Scania with a need to change profoundly and to transform to keep up to speed in a world that is changing faster than ever and where electromobility represents a challenge from a technological, organizational and operational perspective. In this context, corporate culture and change management are challenges, as explained by Director B, e-mobility: “[Our culture] is our strength, but is in some regards our Achilles heel at the same time. We are so trained to eliminate waste and ask why, and trained not to take orders from above... here we are used to work bottom-up. The managers’ role is to ask questions and filter what should bubble up and become something. But if you want to work with transformation and change, you have to point out the direction forcefully and say, ‘now we’re doing this’, and, at the same time, give mandate and the right conditions.” Conversely, a different take on how to overcome the change management challenge was described by Director D, e-mobility: “The culture that we have is that when not everyone is on board, then obviously we haven’t explained the value well enough. Then we have to work on explaining the value and what it is, and then maybe you have to give some carrot, but on the other hand, once you get our system working, it’s very difficult to stop.” Nevertheless, the tension between culture and the need for change is one of the most important challenges to overcome organizationally when transitioning to electromobility, especially because conventional trucks, with all that these imply, in terms of product development and business models, will still be a significant and important part of the business for many years ahead.

Hauliers

From an organization’s perspective, implementing HBEVs entails operational constraints for the hauliers. For instance, the loss of operational flexibility is a challenge. Findings from Study
2 show that the limited range in combination with the lack of infrastructure make HBEVs a less flexible truck than conventional ones – hauliers are not able to drive wherever they want, whenever they want. In other words, they cannot drive everywhere or accept ad hoc, unplanned assignments as with conventional trucks, as explained by CEO of Company B: “On well-defined routes where you drive from A to B, then it’s clear that you will find a solution to charge when you unload and load... On structured, more planned logistical arrangements, there you can use electric vehicles. Otherwise, you lose flexibility with today’s solutions.” Similar findings are presented in studies on challenges of implementing electromobility in different logistics contexts: Dong et al. (2018) for EFVs in city logistics in different European cities, and Melander et al. (2022) for EFVs in city logistics in Stockholm. Notably, Lin and Ho (2011) and Ho and Lin (2012) highlight the complexity and compatibility of technology as a factor influencing the implementation of environmentally friendly practices in logistics systems. In the case of electromobility, HBEVs adds complexity and are, in many cases, less compatible with haulier companies’ current operations. This might inhibit the implementation of HBEVs in road freight transports.

The need for a completely different type of planning is a challenge. Findings in Study 2 indicate that even though the charging infrastructure is in place, charging HBEVs adds new dimensions – the charging time and the need for being able to charge at the right time and the right place. The charging time depends on the available power in the grid, a variable beyond the control of the haulier companies. Being able to charge at the right time and right place is only secured if the haulier company owns the charging equipment or has an agreement at a depot. At public charging stations it is first come, first served, as explained by CEO, Company B: “What I’m terrified of is when we have to start charging on the roads and there are already two trucks when we arrive, and it’s a two–three hour wait, plus the fact that we have to charge as well. Then the entire shift is ruined.” This implies that a different type of planning is required to minimize the risk of operational disturbances, and that is a challenge, as stated by CEO, Company H: “... our planning schedules, our scheduling methods, our way of co-operation with our stakeholders. There is a huge platform that need to be changed, where we have to do things in a different way than we do today. This is not a light change, this needs time.” Additionally, the need for having reliable systems to facilitate the route planning based on available infrastructure is key, as explained by Business Area Manager, Company A: “It’s important to be able to easily find where these charging points are, how many charging points there are, if it will be possible to charge when you get there, so you don’t have to stand there until the next day before you can charge, because then the logistics fail.” Similar results, highlighting the need for more intelligent planning have been pointed out by Quak et al. (2016) in a context of EFVs in city logistics; or as the need for considerable route tailoring, as highlighted by Hovi et al. (2020) in a study of battery-electric trucks in Norway, indicating the complexity that implementing HBEVs entails for the haulier companies. Once more, there is concordance between the literature on challenges of implementing electromobility and electrified road freightts, and the literature on challenges of implementing environmentally friendly practices in logistics contexts in terms of complexity and compatibility (Lin and Ho, 2011; Ho and Lin, 2012). The fact that implementing HBEVs in road freight transports is more than replacing one truck for another is in many cases a huge step for a majority of haulier companies that lack both human resources and the required skills in Information and Communication Technology (ICT) to handle a transition to electromobility. These two factors
are pointed out by Evangelista et al. (2017) as challenges affecting the implementation of green initiatives by logistic companies.

The organizational culture might be a challenge. Other findings in Study 2 indicate that another challenging area when implementing HBEVs is the organizational culture. The road freight transport industry is considered to be conservative: “If you want to generalize a bit, we, as an industry are quite conservative, so we want to feel quite safe and secure before embarking on something new.” (Business Area Manager, Company A); or as explained by the CEO, Company H: “The transport sector is a culture-driven sector... and in a culture-driven sector which goes back far in history, you need a certain [amount of] time to change.” This general industry view is in contrast to the fact that the organizational culture of the individual companies is a decisive factor when deciding to test new technology, as explained by the Fleet Manager of Company G: “One main aspect of the company’s culture is sustainability, and therefore the company is investing a lot in sustainable transport solutions, and we believe that electrification is an important step, or at least part of the sustainable transport solution of the future... The company believes that electrification is an important part of the future and we want to be one of the first movers in this kind of transport solutions because it’s important to understand new technology, the new challenges in order to be able to apply them in the best possible way.” This is a view that was also highlighted by Business Area Manager, Company A: “The company has had the ambition to be early, be prepared and try to see the possibilities.” The view has been corroborated by CEO, Company B: “I think it has a lot to do with governance and management and interest, of course, and the fact that we’ve been doing this it for so long.” Thus, the organizational culture might be a challenge. Similar results have been presented in literature on challenges of implementing electromobility in different logistics contexts: Dong et al. (2018) for EFVs in city logistics in European cities, and Imre et al. (2021) for EFVs in city logistics in Turkey. Moreover, the literature on challenges of implementing GLPs also highlight the organizational culture in terms of lack of management support and lack of management knowledge (Jovanovic et al., 2020) as factors influencing the implementation of green initiatives among haulier companies.

The size of the company is a challenge. Findings in Study 2 indicate that the size of a company is a decisive factor when implementing HBEVs. Large and medium-sized haulier companies have the organizational and financial resources to embark on these kinds of endeavours. They have a larger fleet and a wider customer base, which facilitates the implementation of HBEVs because it is easier for them to find a route, a customer – a viable commercial solution – for the truck. On the contrary, smaller haulier companies lack both the organizational capabilities and the financial strength to address these issues, as stated by Technology Lead Manager, Company C: “Smaller haulage companies do not have the organization to build competencies and the energy to carry out such a transformation. They also lack financial muscles for the investments. Here, vehicle manufacturers can support with expertise to facilitate the transition to electrification.” Thus, the size of the haulier company is decisive and represents a challenge for the implementation of HBEVs. Similar findings have been presented by Oberhofer and Dieplinger (2014), Lin and Ho (2011) and Ho and Lin (2012), where the size of the company has been highlighted as an important factor affecting the implementation of environmentally friendly practices in logistics contexts. Although, the literature on challenges of implementing electromobility in logistics contexts does not highlight the size of the company as a challenge, it is clear that financial strength and organizational capabilities are prerequisites to implementing HBEVs and that a majority of the haulier companies throughout Europe do not
fulfil these basic preconditions. This is in fact the major challenge inhibiting the implementation of HBEVs in road freight transports.

Summary

An overall reflection regarding the organization-related challenges of implementing electromobility, before summarising them is the fact that both the CVM and hauliers are in the middle of a learning process related to the limitations of the technology and of the impact of HBEVs on logistics operations. Organizational cultures are being challenged to make space for new and different ways of working, planning and executing operations within the CVM as well as within haulier companies implementing HBEVs. In line with this, understanding how the implementation of electromobility affects other actors’ organisational culture, for instance the transport buyers, is an interesting area to be explored.

The main perceived organization-related challenges of implementing HBEVs are summarized in Figure 10. For the CVM, the challenges are the resource-intensive and time-consuming selling process, the high level of knowledge and holistic approach required from the sale force, the shift from product to complete solutions when selling HBEVs – the need for a mentality change, the learning process, and the organizational culture. For the hauliers, the challenges are the loss of operational flexibility, the need for a different type of planning for HBEVs, the organizational culture, and the size of company.

6.1.5 Policy-related challenges

Commercial vehicle manufacturers

The policy content is a challenge. The policy-related challenges of implementing HBEVs cannot be underestimated. Findings in Study 1 show that policy is the enabling element that
frames the conditions for the transition to electromobility. It is the policy-makers that have the power to decide about incentives in the form of support for the trucks and the charging infrastructure, punitive taxes on fossil fuels, infrastructure investments, and standardization at a system level. These are the issues that will define the pace of implementation, as stated by Director A, e-mobility: “We also note that the speed to scale is very dependent on other stakeholders. It’s the national authorities, incentives, what the Swedish Transport Administration is doing, charging solutions at system level, they are societal issues.”

Therefore, the scope of the measures – the policy content – to facilitate and incentivize the implementation is a challenge. Similar results are presented by Altenburg et al. (2016), Hovi et al. (2020), Anderhofstadt and Spinler (2020), Melander et. al. (2022), and Imre et al. (2022), which confirms the importance of policy for the implementation of electromobility in road freight transports.

The predictability of policy is a challenge. The automotive industry is used to complying with environmental demands. The challenge lies in having a clear path forward that supports the transition for CVMs, but also other stakeholders in society. Plannability and predictability in policy-making are key when deciding whether to invest in new technology or not, as explained by Director C, e-mobility: “…political stability and sufficient predictability in, e.g., taxes around fuels and energy, how this will develop in the country over the next five years… political long-termism in decisions. As long as there are 4–5-year terms of office and there is a risk of change in political decisions, it’s still too short a time to base an investment decision on.”

Hauliers

The policy content is a challenge. Findings in Study 2 also indicate that regulations and subsidies are considered crucial to the implementation of HBEVs. Regulations are key to prepare the market by setting the frame: “If they [authorities] want sustainable transports, authorities need to have the correct frame for the companies.” This is done by steering investments: “Companies that choose to rearrange their transports or their production must benefit in one way or another” (Business Area Manager, Company A); and by taxation: “The price of diesel would need to be pushed up and the price of electricity pushed down to balance the difference.” (CEO, Company G); “Punitive taxation of fossil fuels would give you a different game plan.” (Business Area Manager, Company A). Thus, the scope of the measures – the policy content – to incentivize the implementation of HBEVs is a challenge. Similar results have been presented in the literature on challenges of implementing electromobility in logistics contexts: see for instance Altenburg et al. (2016), Hovi et al. (2020), Anderhofstadt and Spinler (2020); Melander et. al. (2022), and Imre et al. (2022). Interestingly, the policy perspective is also highlighted in the literature on challenges of implementing environmentally friendly practices in logistics systems: see, for instance, Oberhofer and Dieplinger, (2014), Abassi and Nilsson (2016), Evangelista et al. (2017), and Jovanovic et al. (2020). This indicates a concordance between the two literature streams.

The predictability in policy-making is a challenge. Findings in Study 2 show that the role of policy is considered crucial by the hauliers as well. The coordinating role of authorities and policy is determinant because it frames the speed and the magnitude of the transition and, therefore, is considered a challenge, as explained by Logistics Strategy Director, Company F: “The big challenge from a societal perspective is that society should not dare to accept the
tipping point: that you stick to old technology because it’s politicians who have to make these decisions, and there is always someone who wants to preserve the old for longer than it really should be allowed to exist.” In addition, policy-makers and policy-making are regarded as a risk: “It would be difficult to be the party who has invested strongly in electrical vehicles, and then the goals are postponed. That’s still the risk.” (CEO, Company H). Similar results have been presented by Abbasi and Nilsson (2016) and Evangelista et al. (2017).

Summary

The policy-related challenges of implementing HBEVs are summarized in Figure 11. Noticeably, for both the CVMs and the hauliers, the challenges lie in the predictability of policies as well as their content. In general, both the CVMs and hauliers refer to the same policy content, with some nuances. The fact that the policy-related challenges are almost the same, reveals the overarching, coordinating and enabling role of policy for the transition to electromobility and, thereby, the implementation of HBEVs in road freight transports.

Figure 11. Policy-related challenges

6.2 How can challenges of implementing HBEVs be interrelated? Answering RQ2

The importance of understanding the interrelations between the challenges of the CVM and the hauliers, and the interrelations among the challenges in the different categories, serves two purposes. First, understanding the interrelation between the challenges of the CVM and the challenges of the hauliers helps to point out areas where the CVM can support, make a difference and, thereby, is able to create value for the hauliers. Second, understanding the interrelations among the challenges in the different categories is imperative to understand the complexity that the implementation of HBEVs entails, as well as the inhibiting effect of the challenges, because in some cases the challenges have a reinforcing effect. This increases the complexity and the inhibiting effect of the challenges, making the transition to electromobility and HBEVs even harder for the hauliers.

Figure 12 illustrates the interface between the CVM and hauliers represents the market for HBEVs solutions. It’s in this market where the challenges of implementing HBEVs are materialized. Given the relationship between CVMs, as technology providers, and hauliers, as technology adopters, many of the challenges, but not all of them, can be described as two sides of the same coin, a dichotomy. The following sections aims to describe the interrelatedness
between in each category, and among the challenges across all categories described throughout RQ1.

6.2.1 Technology-related challenges

In Figure 13, the interrelations between the technology-related challenges are illustrated. The challenges of the CVM on the left side of the figure – battery capacity and battery weight and the lack of infrastructure – correspond to the challenges from the hauliers’ perspective, on the right side in the same figure. The battery capacity, a challenge for the CVM, has a direct impact on the range of the trucks and becomes a challenge for hauliers. The battery weight, a challenge for the CVM, has a direct impact on the load-carrying capacity, the payload, of the trucks and becomes a challenge for the hauliers. Important to highlight is the fact that the range and the load-carrying capacity have an impact on business and operations, which will be discussed at the end of this section. In addition, the fact that the lack of infrastructure has been pointed out by a majority of the participants interviewed during the studies, and is considered to be the most decisive challenge to be overcome, denotes the preponderance that infrastructure – charging points and grid capacity – has for a successful implementation of HBEVs in road freight transports. Finally, the challenge concerning the development pace of the technology and its implication in being the source of uncertainty among hauliers, is an aspect that CVM has taken into account. In the case of Scania this challenges is dealt with by actions in the sales organization, which are described in the appended case report.
Having the technology-related challenges as the starting point of the discussion serves two purposes. First, it emphasizes that the implementation of HBEVs in road freight transports is a technology-driven transition, as stated at the beginning of this section. Second, it highlights the fact that the technology and the succeeding technology-related challenges are the root cause to the challenges related to finance, market, and organization, that will be discussed throughout this sections when answering RQ2.

6.2.2 Finance-related challenges

In Figure 14, the interrelations between finance-related challenges are illustrated. On the right side of the figure, the high market price of HBEVs in combination with the need for investing in charging infrastructure, represent a challenge for the hauliers in the form of high initial investments – one of the main inhibiting factors to the implementation of HBEVs. Another identified challenge for the haulier is the uncertainty concerning the residual value of HBEVs, an important component affecting the investment decision and perceived as a major risk from the hauliers’ perspective. Moreover, the fact that the residual value has a direct impact on the trucks’ TCO reinforce even more the necessity of finding suitable financial solutions. These three financial-related challenges for the hauliers are interrelated to one major financial-related challenge of the CVM – finding suitable business models and suitable financial solutions to de-risk the implementation of HBEVs for the hauliers.

6.2.3 Market-related challenges

Surprisingly, there appears to be no interrelations between the market-related challenges of the CVM and the hauliers as depicted in Figure 15. The explanation to that lies in the fact that “the market” for each one of these two actors is not the same, as explained in previous sections. The market for the CVMs – the market for HBEVs – lies in the interface between CVMs and the transport networks, and is constituted by the haulier companies. The market for haulier companies – the transport market – lies in the interface between the freight flow and the transport network, and is constituted by the transport buyers.

Moreover, the absence of interrelations between the market-related challenges of the CVM and the hauliers raises the question of current and future relationship between CVMs and transport buyers and how these can support and accelerate the implementation of HBEVs in road freight transports.
6.2.4 Organization-related challenges

In Figure 16, the interrelations between organization-related challenges are illustrated. Although the challenges on both sides of the figure are mostly related to operations they differ on their perspective. The challenges on the left side of the figure describe the organization-related challenges from a sales perspective – new products based on new technology needs to be sold and implemented. The challenges on the right side derive from the actual implementation of HBEVs in the hauliers’ daily operations.

The loss of flexibility and the need for a completely different type of planning when implementing and operating HBEVs creates a need for the CVM to understand the haulier’s operations – their logistics set-up – to be able to guide and support the haulier when implementing HBEVs. This is the starting point for a learning and selling process that is resource-intensive and time-consuming, that requires a high level of knowledge and a holistic approach from the CVM’s side to understand the type of solution needed in the form of truck and infrastructure. This, in turn, requires a change in mentality to focus on complete solutions aimed at meeting customer need.

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![Figure 15. Interrelations between market-related challenges](image1)

![Figure 16. Interrelations between organization-related challenges](image2)
Furthermore, even though there is no interrelation between the organizational culture of the CVM and the hauliers, some similitudes can be perceived. The novelty of electromobility and the novelty of HBEVs challenge old traditions, practices and conventions, and creates a need for change to make space for the technology itself. This represents a challenge per se because old traditions, practices and conventions cannot be changed overnight due to pride, history, habits, preconceptions, among others, and are elements that can delay the transition to electromobility and HBEVs.

In addition, another ambiguous interrelation, between the size of the haulier company and the fact that selling a HBEV is resource-intensive and time-consuming, can be recognized. A small haulier company should need considerably more support than a bigger company, which leads to the question – how many small haulier companies can embark on such an endeavour as implementing HBEVs? This is especially the case because selling HBEVs for the first time is extremely resource-intensive and time-consuming.

6.2.5 Policy-related challenges

In Figure 17, the interrelations between the policy-related challenges are illustrated. In the figure below it can be observed that the policy-related challenges are similar from the perspectives of both CVM and hauliers. First and foremost, the challenge of predictability in policies and policy-making has been highlighted by a majority of interviewees in both Study 1 and Study 2. Policy is the element that frames and defines the conditions for all the stakeholders involved in the transition to HBEVs. The absence of political predictability and long-termism is considered to inhibit the implementation of HBEVs. Without this element it is difficult to make investments in expensive technology, and this will harm a scale up process.

Additionally, when it comes to policy content the challenges ahead are quite similar as well. Incentives in the market for the CVM means subsidies for the hauliers. Punitive taxes on fossil fuels for the CVM is the same as taxation for the hauliers. Standardization at a system level of technical solutions is part of the regulative nature of policy and is mirrored on the hauliers’ side by the challenge concerning regulations aimed at setting the frame and preparing the market.

![Figure 17. Interrelations between policy-related challenges](image-url)
6.2.6 Interrelatedness among challenges and categories

To answer RQ2 thoroughly, it is necessary to highlight that the challenges of implementing HBEVs are not only interrelated as described in the preceding sections, but also interrelated among the different categories. In Figure 18, the challenges described in previous sections and some interrelations between challenges across the different categories have been depicted.

Figure 18. Interrelations between challenges across the different categories
Understanding the interrelations among the challenges in the different categories is imperative because, in some cases, the challenges have a reinforcing effect, which inhibits even further the transition to electrified freight transports for the hauliers. Implementing HBEVs is complex because challenges, of different nature, need to be overcome simultaneously.

In Figure 18, some of the multidimensional interrelatedness between the challenges are illustrated. For instance, if the red-coloured arrows are followed an interrelation between challenges in different categories emerges. (a1) The high market price of HBEVs (market-related challenge) results in high initial investments for the haulier (financial-related challenge). (a2) The hauliers companies would benefit from policies, e.g. subsidies (policy-related challenge) that support a transition to HBEVs. (a3) In addition, due to the financial implications of the high initial investments (financial-related challenge), the haulier companies need to secure longer contracts and the utilization rate of the vehicles (market-related challenge), that depends on the (a4) transport buyers. The utilization rate, on the other hand, is limited by (a5) the range of HBEVs and (a5) the lack of infrastructure (technology-related challenges).

If the blue-coloured arrows are followed, another interrelation between challenges in different categories emerges. For instance, (b1) the limited battery capacity entails a limited range for HBEVs (technology-related challenge). (b2) The limited range results in a loss of operational flexibility for the hauliers as well as (b3) a need for a completely different type of planning daily operations (organization-related challenges). In addition, (b4) the limited range of HBEVs and the loss of operational flexibility affect the utilization rate of the vehicle (market-related challenge) and this is further reinforced by (b5) the lack of infrastructure (technology-related challenge).

If the yellow-coloured arrows are followed, (c1) the interrelation between the market-price of HBEVs (market-related challenge) and the negative impact it has on the TCO (finance-related challenge) is illustrated. The TCO is also negatively impacted by (c2) the residual value of HBEVs (finance-related challenge), which in turn is negatively impacted by (c3) the development pace of the technology (technology-related challenge). In order to improve the TCO, haulier companies need to (c4) secure longer contracts and the utilization rate of the vehicles (market-related challenge), that depends on the (c5) transport buyers.

A conclusion drawn from Figure 18 is that the interrelations between challenges in different categories shed light on the multidimensionality and complexity that the implementation of HBEVs entails. In addition, the interrelations between challenges in different categories also show how these interrelations have a reinforcing effect on the challenges, and thereby, might inhibit the implementation, and ultimately, the adoption of HBEVs in road freight transports.

In the figure, only the challenges described in RQ1 have been set up. If the list of challenges is increased, the resulting possible interrelations will be increased in many ways and combinations – Figure 18 only offers a few examples. Thus, the interrelatedness of challenges is a subject for further research to fully understand the complexity of implementing HBEVs in freight transport.

Furthermore, another conclusion taken from Figure 18 is that, despite the challenges faced by the CVM, it is the challenges faced by the hauliers that need to be resolved. These challenges also constitute a source of value creation opportunities for the CVMs. The role of the CVMs is to develop and deliver appealing solutions, or value propositions, to facilitate and de-risk the
Implementation of HBEVs in road freight transports from a financial, operational, and, if possible, even a market point of view.
7. Conclusions and Future research

The final and concluding chapter of this thesis is structured in three sections. In the first section the research questions aiming to fulfil the purpose of the thesis are answered. This is followed by a section presenting the contribution of the thesis and, finally areas of future research are presented.

7.1 Answering the research questions and purpose

In the previous chapter, the empirical findings in Study 1 and Study 2 were presented to answer the research questions and to fulfil the purpose of this thesis - *Describe and explain the challenges of implementing HBEVs for Commercial vehicles manufacturers and Hauliers*. In the following section the research questions will be addressed to fulfil the purpose.

7.1.1 Describing the challenges of implementing HBEVs

The empirical findings in the thesis revealed that the challenges of implementing HBEVs are of a different nature. To answer research question 1 – *How can the challenges of implementing HBEVs be described?* – the frame presented by Jovanovic et al. (2020) was found to be an appropriate approach to structure and describe the challenges. Consequently, the challenges of implementing HBEVs have been categorised into five areas: technology, finance, market, organisation and policy. Table 8 summarizes the identified challenges.

<table>
<thead>
<tr>
<th>Category</th>
<th>Commercial vehicle manufacturers</th>
<th>Hauliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology</td>
<td>• Battery capacity</td>
<td>• The limited range</td>
</tr>
<tr>
<td></td>
<td>• Weight of the battery</td>
<td>• The load-carrying capacity</td>
</tr>
<tr>
<td></td>
<td>• Lack of infrastructure</td>
<td>• The lack of infrastructure</td>
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<td></td>
<td>• Finding suitable business</td>
<td>• The development pace of the technology</td>
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<td></td>
<td>models with appropriate financial solutions</td>
<td></td>
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<tr>
<td>Finance</td>
<td>• The market price of HBEVs</td>
<td>• The high initial investments</td>
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<tr>
<td></td>
<td>• The residual value</td>
<td>• The residual value</td>
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<tr>
<td></td>
<td>• The product portfolio</td>
<td>• The TCO</td>
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<tr>
<td></td>
<td>• The aftermarket</td>
<td>• The commitment and support of transport buyers</td>
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<tr>
<td>Market</td>
<td>• Resource-intensive and time-consuming selling process</td>
<td>• Securing longer contracts and high utilisation rates</td>
</tr>
<tr>
<td></td>
<td>• The need for high level of knowledge and holistic approach</td>
<td>• Getting higher fees from greener transports</td>
</tr>
<tr>
<td></td>
<td>• The shift from product to complete solutions - the change in mentality</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The learning process</td>
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<td></td>
<td>• The organizational culture</td>
<td></td>
</tr>
<tr>
<td>Organisation</td>
<td>• Policy predictability</td>
<td>• Loss of operational flexibility</td>
</tr>
<tr>
<td></td>
<td>• Policy content</td>
<td>• The need for a completely different type of planning</td>
</tr>
<tr>
<td></td>
<td>• Incentives</td>
<td>• The organizational culture</td>
</tr>
<tr>
<td></td>
<td>• Punitive taxes</td>
<td>• The use of company</td>
</tr>
<tr>
<td></td>
<td>• Standardisation</td>
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<tr>
<td>Policy</td>
<td>• Policy predictability</td>
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<td>• Policy content</td>
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<td></td>
<td>• Incentives</td>
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<td>• Subsidies</td>
</tr>
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<td></td>
<td>• Standardisation</td>
<td>• Taxation</td>
</tr>
</tbody>
</table>
Although all challenges are important, some of them have a greater inhibiting effect for the implementation of HBEVs:

- *The lack of infrastructure* has been highlighted as one of the main challenges for the implementation of HBEVs. Infrastructure is considered to be a prerequisite that needs to be deployed at a faster pace than today. The lack of infrastructure is a systemic challenge that cannot be solved by the CVMs and hauliers, but requires the involvement of other actors.
- *The price and the high initial investments* are also considered to be another main challenge for the implementation of HBEVs. These two elements have an inhibiting effect on all haulier companies, but are much more difficult to overcome for companies that lack financial resources. The necessity to de-risk the transition and the implementation of HBEVs for the hauliers is crucial to scale-up this type of trucks in logistics operations.
- *Policy’s enabling role* for the implementation of HBEVs – in terms of predictability and content – have been highlighted as one of the main challenges as well. Policy’s predictability long-term is considered to be decisive for the transition, as this allows companies to plan investments without unexpected surprises. Policy’s content is considered to be the enabling force paving the way, and supporting all actors involved in this process.

### 7.1.2 The interrelatedness of the challenges

As a response to research question 2 – How can challenges of implementing HBEVs be interrelated? – the interrelatedness of the challenges have been depicted in each one of the categories used to described the challenges in research question 1.

The interrelatedness of the challenges of implementing HBEVs has shown the critical role of the CVM, as technology provider, for the hauliers when implementing this new vehicle technology. For instance, the interrelatedness of the challenges can, in many cases, be described as a reflection – a dichotomy – where the challenges of the hauliers are mirrored by a challenge of the CVM, that is to say, a challenge of the hauliers becomes a challenge for the CVM.

Moreover, the absence of interrelations of market-related challenges between the CVM and the hauliers highlight and emphasize the crucial role that the transport buyers play for the hauliers and, ultimately, for the CVM, in the implementation of HBEVs. For instance, the attitude and preferences of the transport buyers cannot be overlooked on issues related to the impact of the new technology on transport fees, on utilizations rates, on the flexibility of logistics systems, and on changes to current logistics transport solutions.

Furthermore, the interrelatedness among the challenges in the different categories – technology, finance, market, organization and policy – show the complexity that the implementation of HBEVs entails for both the CVM and the hauliers. In addition, the interrelatedness shows the
reinforcing effect of the challenges, for instance a technology-related challenge *(limited range)* becomes an organizational-related challenges *(loss of operational flexibility)*, that becomes a market-related challenge *(hard to secure utilization rate)*, that have financial-related implications *(TCO affected negatively)*.

Finally, the interrelatedness show the need of a holistic approach and systems solutions to facilitate the implementation of HBEVs, and show that the challenges of the transition to HBEVs are not solely about a technology shift, the challenge is systemic. To overcome this, the involvement of the technology providers, the infrastructure providers, the transport buyers and policy-makers, is required, as illustrated in Figure 19. In the figure below, the traditional interaction between the CVM and the hauliers when selling a conventional truck (red square), is replaced by the involvement of and the interaction between actors in all systems (blue square).

![Figure 19. The involvement and interaction to overcome the challenges (adapted from Wandel et al. (1992))](image)

7.2 Contributions

This thesis contributes to the body of research on electromobility and the body of research on green logistics, specifically the intersection of both fields.

7.2.1 Contribution to research

This thesis, focusing on Heavy-duty Battery Electric Vehicles (HBEVs), contributes to the body of research on electromobility by extending the general view on challenges of implementing electromobility in road freight transports to also include HBEVs. Previous research on challenges of implementing electromobility in road freight transport is based, to a large extent, on studies focusing on light freight vehicles operating in urban logistics contexts (Melander et al., 2022; Dong et al., 2018; Quak et al., 2016), due to the novelty of HBEVs on the market. Another contribution of this thesis is that the perspective of the Commercial Vehicle Manufacturers (CVMs) has been included to describe and shed light on the challenges of implementing HBEVs from the technology providers point of view. Moreover, the thesis highlight the managerial and business-related aspects of the implementation for both CVMs and hauliers. For instance, the decisive role of the transport buyers for the implementation of
HBEVs, or the influence of the organisational culture for transitioning to this new technology among others. Furthermore, this thesis describes the multidimensionality and complexity of implementing electromobility by elucidating the interrelatedness of the challenges and how these interrelations have a reinforcing effect that might inhibit the implementation of HBEVs even further.

Likewise, the contribution of this thesis to the body of research on green logistics, extends the literature on the challenges of implementing Green Logistics Practices (GLPs), especially the implementation of new vehicle technology. Moreover, the thesis contributes to the body of research on green logistics by incorporating the actors’ perspectives to better understand the electrification of transport and logistics systems as highlighted by Gillström et al. (2023). In addition, another contribution to the body of research on green logistics is the inclusion of the perspective of the technology provider on the challenges of implementing HBEVs and their role in the transition to greener transport solutions. The body of research on supply chain management has given little attention to the relation between the CVMs, as technology providers, and the hauliers, as technology adopters (see e.g. Gutierrez et al., 2022).

7.2.2 Contribution to practitioners

This thesis contributes to practitioners outside academia in several ways. First, by highlighting the main challenging areas of implementing HBEVs in road freight transports, practitioners can get insights on the challenges itself. In addition, the categories presented in this thesis, based on the framework of Jovanovic et al. (2020), are a useful tool to map challenges related to the electrification of logistics systems in a structured way.

Second, by highlighting the managerial and business-related aspects of the implementation, a dimension is added – it’s not only the technological limitations that matter for the CVM when implementing HBEVs. The consequences on the hauliers’ businesses and organisations are equally important. For instance, the importance of the transport buyers for the implementation of HBEVs have been highlighted; the role of the organisational culture has been acknowledged; and the importance of policies for investment decisions has been pointed out among others.

Third, the inclusion of the CVM-perspective sheds light on the fact that the implementation of HBEVs also entails challenges to these organisations as well, and contribute to a better understanding of their role, as technology providers, in facilitating the implementation of HBEVs for the hauliers.

Forth, the explanation of the interrelatedness between the challenges across the different categories, contributes to the understanding of the multidimensionality and complexity of the implementation of this new technology. This would be relevant to all actors in the implementation process, both those studied and others such as transport buyers as well as providers of energy and charging infrastructure.

Finally, a last contribution of this thesis is the highlighting of the decisive role of policy and policy-makers for the transition to electromobility, and the notable concordance in expectations, from both CVMs and hauliers, in terms of predictability long-term and content.
7.3 Future research

The empirical findings in Study 1 and Study 2 provide interesting themes as possible paths for future research. For instance:

- **How will the role of the transport buyers in the transition to electromobility in terms of acceptance of radical changes in current logistics systems/operations? Will the technology adapt to the existing logistics system or will new logistics systems emerge to suit the technology?**

  Findings suggest that the role of the transport buyers is decisive for the hauliers when implementing HBEVs. The implementation of this new type of truck might result in the need to undertake radical changes in the current logistics operations to facilitate a transition on a larger scale. For that, the attitude and preferences of the transport buyers cannot be overlooked on issues related to the impact of the new technology on transport fees, utilizations rates, flexibility, and changes on current logistics transport solutions/systems.

- **How will the future financing and owning models of HBEVs be structured? What type of financial solutions approaches will be available to reduce the financial risks of CVMs and hauliers?**

  Findings suggest that the financial risks connected to the implementation of HBEVs are important elements that inhibit the implementation of this new type of trucks. The need to de-risk the transition from a financial point of view, for both technology providers as well as technology adopters, calls for innovative financial solutions.

- **How can value creation mechanisms and value propositions, of CVMs and hauliers, be described in the context of electrified freight transports?**

  As the implementation of HBEVs entails complex and multidimensional challenges. In this context, aspects concerning value creation as well as value propositions becomes more important for both CVMs towards the hauliers; and the hauliers towards the transport buyers; but also between the CVMs and the transport buyers. The interface between CVMs, hauliers and transport buyers is an interesting area to research.
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Papers

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https://doi.org/10.3384/9789180755863
Roadblocks to Implement Electric Freight Transports

Challenges for Commercial Vehicle Manufacturers and Hauliers