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How Ecosystem Actors Manage Opportunities and Challenges through Business Model Innovation

A Case Study on the Electrification of Heavy Road Transport along E16 Borlänge – Gävle Hamn

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Stockholm, Sweden 2022

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Master of Science Thesis TRITA-ITM-EX 2022:217
KTH Industrial Engineering and Management
Industrial Economics and Management
SE-100 44 STOCKHOLM

Hur ekosystemsaktörer hanterar möjligheter och utmaningar genom affärsmodellsinnovation

En fallstudie av elektrifieringen av tunga vägtransporter längs E16 Borlänge – Gävle Hamn

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Approved	Examiner	Supervisor
2022-06-07	Mats Engwall	Adam Uhrdin
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Abstract

The electrification of heavy road transport is ongoing in Sweden. Multiple electrification technologies are emerging and electric truck models are being added to the product portfolios of the truck manufacturers. However, questions have remained regarding how the electrification of heavy road transport will unfold in practice, as it has been unclear what roles the actors of the emerging electric heavy road transport ecosystem will enact in terms of who should finance, build, own, operate and use the technical components deemed critical to the transition. This thesis addresses this issue through a case study on the electrification of heavy road transport along E16 Borlänge - Gävle Hamn, based on interviews with representatives of goods owners, haulage contractors, truck manufacturers, the port authority, electrical grid owners and charging infrastructure companies. By exploring the varying perceptions of the transition to electric heavy road transport, the studied case provides insight into how ecosystem actors manage opportunities and challenges through business model innovation and in effect contribute to the development of the ecosystem.

First, the thesis addresses how the ecosystem actors perceive business model opportunities and challenges with the transition to electric heavy road transport, what roles these actors could potentially consider enacting in the transition and what roles are considered critical. From the interviews with representatives of the ecosystem actors, a wide range of opportunities and challenges are identified, as well as differing perceptions of specific opportunities, challenges and roles. It is argued that these differing perceptions add to the complexity of the emerging ecosystem, in addition to the multilateral and complementary relationships between actors, and that such complexity could be managed by one or several ecosystem actors enacting a leadership role to guide ecosystem development at its early stages.

Second, how the ecosystem actors manage the perceived opportunities and challenges through business model innovation and thus participate in the development of the ecosystem is addressed. From the interviews with representatives of the ecosystem actors, the ecosystem actors are demonstrated to innovate all but one sub-component of the business model to manage these opportunities and challenges, where some actors are innovating to a greater extent than others and in turn managing a greater number of opportunities and challenges. In addition, some ecosystem actors are demonstrated to proactively innovate their business model to drive ecosystem change, as compared to the ecosystem actors who reactively innovate their business model to adapt to change. It is argued that it is the ecosystem actors who proactively innovate a great number of sub-components of the business model who will enact a leadership role and steer the development of the ecosystem, whereas the other actors follow and will have to adapt to the ecosystem leaders. Thus, by combining ecosystem and business model innovation theory, it is demonstrated that in addition to that development at an ecosystem level induces business model innovation, business model innovation inversely induces ecosystem level development.

Key-words

Business model, business model innovation, ecosystem, ecosystem roles, electrification, heavy road transport, sustainable transport

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2022-06-07	Mats Engwall	Adam Uhrdin
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Sammanfattning

Elektrifieringen av tunga vägtransporter fortgår i Sverige. Flera elektrifieringstekniker växer fram och elektriska lastbilsmodeller adderas till lastbilstillverkarnas produktportföljer. Frågor kvarstår dock angående hur elektrifieringen av tunga vägtransporter kommer att utvecklas i praktiken, eftersom det har varit oklart vilka roller aktörerna i det framväxande elektriska tunga vägtransportekosystemet kommer att ta när det gäller vem som ska finansiera, bygga, äga, drifta och använda de tekniska komponenter som anses vara avgörande för denna övergång. Detta examensarbete adresserar detta problem genom en fallstudie av elektrifieringen av tunga vägtransporter längs E16 Borlänge - Gävle Hamn, baserad på intervjuer med företrädare för godsägare, åkerier, lastbilstillverkare, hamnmyndigheten, elnätsägare och laddinfrastruktursföretag. Genom att utforska de varierande uppfattningarna av övergången till elektrifierad tung vägtransport, bidrar fallstudien med insikter i hur ekosystemsaktörer hanterar möjligheter och utmaningar genom affärsmodellsinnovation och därmed bidrar till ekosystemets utveckling.

Först och främst behandlar examensarbetet hur ekosystemsaktörerna uppfattar affärsmodellsrelaterade möjligheter och utmaningar med övergången till elektriska tunga vägtransporter, vilka roller dessa aktörer potentiellt skulle kunna tänka sig att ta i övergången och vilka roller som anses vara kritiska. Från intervjuerna med företrädare för ekosystemsaktörerna identifieras ett stort antal möjligheter och utmaningar, samt olika uppfattningar om specifika möjligheter, utmaningar och roller. Dessa olika uppfattningar påstås bidra till komplexiteten i det framväxande ekosystemet, utöver de multilaterala och komplementära relationerna mellan dessa aktörer. Dessutom tyder resultaten på att sådan komplexitet skulle kunna hanteras av en eller flera ekosystemsaktörer som intar en ledarroll för att på så vis vägleda ekosystemsutvecklingen i dess tidiga skede.

Vidare behandlas frågan kring hur ekosystemsaktörerna hanterar de upplevda möjligheterna och utmaningarna genom att innovera sina affärsmodeller och hur de därmed deltar i utvecklingen av ekosystemet. Från intervjuerna med företrädare för ekosystemsaktörerna påvisas det att ekosystemsaktörerna utvecklar alla utom en delkomponent av affärsmodellen, för att hantera möjligheter och utmaningar. Det framgår även att vissa aktörer innoverar sin affärsmodell i en större utsträckning än andra aktörer och därmed hanterar en större mängd möjligheter och utmaningar. Därtill belyses det att vissa ekosystemsaktörer förnyar sin affärsmodell på ett proaktivt sätt för att driva ekosystemsförändring, jämfört med de ekosystemsaktörer som förnyar sin affärsmodell reaktivt för att anpassa sig till förändring. Resultatet pekar också på att det är de ekosystemsaktörer som proaktivt förnyar ett stort antal delkomponenter av affärsmodellen som kommer att ta en ledarroll och styra utvecklingen av ekosystemet, medan resterande aktörer följer efter och kommer att behöva anpassa sig till ekosystemsledarna. Således, genom att kombinera ekosystems- och affärsmodellsinnovationsteori, påvisas det att utöver att utveckling på en ekosystemsnivå kan medföra affärsmodellsinnovation, kan affärsmodellsinnovation omvänt medföra ekosystemsutveckling.

Nyckelord

Affärsmodell, affärsmodellsinnovation, ekosystem, ekosystemsroller, elektrifiering, tung vägtransport, hållbara transporter

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Foreword

This thesis has been written on behalf of Siemens AB, why we would like to direct our sincere gratitude to our supervisor Jakob Ingvar-Nilsson, Business Segment Manager - eMobility Sweden, who has given us invaluable feedback on our work. It has been a great pleasure to get to know him as well as the many other Siemens colleagues during the spring.

In addition, our academic supervisor Adam Uhrdin, Postdoc at KTH, Ph.D. Management and Technology, has guided us throughout the process of writing this thesis, which we are hugely grateful of.

Lastly, we would like to say thank you to all of the interviewees, who committed their time and effort to provide us with the qualitative data required to write this thesis, and in effect supported the transition to sustainable transport.

Gustav Hedman & Robin Lindfors
Stockholm, June 2022

1. Introduction

1.1 Background

The transport sector accounts for roughly one third of global CO_2-emissions, out of which the majority of emissions can be attributed to road transport (IEA, n.d.). Electrification is considered as one path towards decarbonising and mitigating the emissions of the road transport sector. The passenger road segment has seen a considerable uptake of electric vehicles (EVs) in recent years, with 3 million new EVs being registered in 2020 and the global EV stock totalling 10 million vehicles, representing 1% of the global stock of passenger cars (IEA, 2021a). Simultaneously, publicly accessible fast and slow EV chargers increased to 1.3 million units (Ibid). The heavy transport sector on the other hand, including road trucking, maritime shipping and aviation, is considered one of the harder-to-abate sectors due to technologies enabling decarbonisation not being fully commercially available (IEA, n.d.). Heavy trucking, also referred to as "road freight transport" or "heavy road transport", accounted for 25% of the global transport sector's CO_2-emissions in 2020 (IEA, 2021b). In the same year, 6.2 million heavy trucks were in circulation in the EU alone (ACEA, 2021a), out of which only 450 of them were electric ones (IEA, 2021c).

The fleet of electric heavy trucks is however growing, as all major European truck manufacturers (i.e. Volvo Trucks, Scania, MAN and Daimler) are adding several electric models to their product portfolios and are aiming to begin mass production within the next few years (Power Circle, 2021a). As regards electric heavy truck charging infrastructure, a range of technologies are currently being developed and commercialised. Siemens and ABB are two examples of companies with high power stationary charging infrastructure suited for electric heavy trucks in their product range (Siemens, n.d.; ABB, n.d.). Besides stationary charging technologies, dynamic charging technologies, also referred to as "electric road technologies" or "electric road systems" as well as hydrogen fuel cell alternatives, are under development. There are multiple ongoing demonstration projects where these technologies are being tested and besides the frontrunner Germany, Sweden is leading the way in the development of electric heavy road transport. The heavy road transport sector accounts for roughly a third of the total domestic road traffic emissions and thus around 6.5% of total emissions in Sweden (Fossil Free Sweden, 2020). Twenty-two Swedish industries including the heavy transport automotive industry have developed roadmaps for how to achieve net-zero emissions by 2045 on a national level (Fossil Free Sweden, n.d.). Besides increased transport efficiency and a higher proportion of biofuels, electrification is considered a key strategy to decarbonising the Swedish heavy road transport sector (Fossil Free Sweden, 2020).

In 2021, there were 86,000 heavy trucks registered in Sweden accounting for more than three quarters of the total amount of goods transported domestically (Trafikanalys, 2022), a number which is estimated to increase to 120,000 heavy trucks by 2040 (Power Circle, 2021a). In April 2022, only 104 of the registered heavy trucks were electric (Power Circle, 2022). The charging infrastructure adapted to the high power needs of heavy trucks is currently next to non-existent, and the European Automobile Manufacturers' Association (ACEA) has estimated that 40,000-50,000 charging points will be required by 2030 to achieve the European climate goals, out of which 1,200 charging points are to be located in Sweden (ACEA, 2021b). This calls for a drastic build-out of heavy truck charging infrastructure with secured electrical grid power in combination with an accelerated deployment of electric heavy trucks, to enable the electrification of heavy road transport in Sweden.

1.2 Problematisation

The transition towards electric heavy road transport entails an integration of the electricity and transport sectors. As a consequence, a complex ecosystem of actors with multilateral relationships emerges, including traditional transport sector actors such as truck manufacturers, transport buyers, haulage contractors and intermodal hub (e.g. port) operators; traditional electricity sector actors such as electricity suppliers and distribution network operators; as well as the emerging charging infrastructure suppliers and operators, who all need to cooperate to enable the transition. Adding to the complexity is the multiple available technological solutions for electrifying the heavy road transport sector, including stationary charging, electric road systems and hydrogen fuel cells. An integral question which needs to be addressed is who should participate in the key activities of financing, building, owning, operating and using the charging infrastructure, the electric heavy trucks and other components critical to the ecosystem and the value proposition of the respective actors? In turn, how might the actors of the emerging electric heavy road transport ecosystem transform their current business models to engage in and enable this transition?

1.3 Purpose

This thesis, written on behalf of Siemens AB, aims to accelerate the transition towards electric heavy road transport by addressing what role ecosystem actors will enact in the future and how their business models need to develop to enable the transition, through a case study on the electrification of heavy road transport along E16 Borlänge-Gävle Hamn in Sweden. The studied case is a stretch of road along which numerous companies within the local mining, steel, forestry and pulp and paper industries are located, which are dependent on goods transportation by road to and from the local port. As such, the studied case could greatly benefit from the transition to electric heavy road transport, in addition to the region already having shown great interest in the transition, as there has for instance been conducted an ERS demonstration project during the years 2013-2020 in the region (Region Gävleborg, 2021). Another reason for studying this specific case is due to pragmatic reasons, as Siemens AB is involved in business relationships with many of the companies in the region, companies which should consequently be more inclined to cooperate and provide the qualitative data required to fulfil the aim of the thesis.

1.4 Research Questions

The above purpose will be fulfilled by answering the following research question:

RQ1: *How do ecosystem actors perceive the transition to electric heavy road transport in terms of business model opportunities and challenges?*

Additionally, by combining business model innovation and ecosystem theory and applying it to the studied case, the thesis aims to answer a second research question, namely:

RQ2: *How do ecosystem actors innovate their business models to manage perceived business model opportunities and challenges, in order to play a role in the development of the electric heavy road transport ecosystem?*

1.5 Contribution

By answering the two research questions, the expected contributions of this thesis are of both practical and theoretical nature. As regards practical contribution, by exploring opportunities and challenges to the electrification of heavy road transport as perceived by the ecosystem actors and by investigating which role the respective actors are willing to take in the transition to electric heavy road transport, this thesis will illustrate how the transition could unfold in practice, which previous inquiries into the electrification of heavy road transport have not yet demonstrated (Power Circle, 2021a; RISE, 2021). As such, the studied case could pose as an example for and provide insights to other regions transitioning to electric heavy road transport with similar characteristics as the studied case. In addition, whereas previous studies have mainly focused on electric road systems, this thesis applies a broad perspective by including multiple electrification technologies, namely stationary charging, electric road systems and hydrogen fuel cells, to enhance the knowledge about the complementary relationship between the technologies. As regards theoretical contribution, this thesis will add to the limited literature (e.g. Rong et al., 2018) within the research area at the intersection of ecosystem theory (e.g. Adner, 2017) and business model (innovation) theory (e.g. Foss & Saebi, 2017). The thesis will investigate how the individual actors of an ecosystem might rework their respective business models, in terms of value proposition, value creation and value capture, to manage perceived opportunities and challenges in order to jointly be able to offer electrified heavy transport services to the transport buyer.

1.6 Delimitations

The thesis is delimited to the heavy truck segment of the road transport sector. This implies delimiting the thesis to road vehicles set up mainly for freight transport and with a total weight exceeding 3.5 tonnes, in line with the Swedish Transport Agency's definition of a heavy truck (Transportstyrelsen, 2013). The thesis is also delimited to regional transport on public roads between industrial areas, effectively excluding transport within industrial areas. Further, the scope of the thesis is the electrification of heavy road transport in general, and thus includes both stationary and dynamic charging technologies, as well as hydrogen fuel cell technologies. As such, the thesis is not delimited in terms of electrification technologies, but rather by the activities and technical components deemed critical to realise the transition to electric heavy road transport within the studied case.

The studied case is delimited to highway E16 between Borlänge and Gävle Hamn and its surroundings, including the Avesta region in the south located along National Road 68. The actors included in the study are actors involved in and affected by the electrification of heavy road transport within this geographical region. The electrification of heavy road transport affects and is affected by numerous actors. However, with regards to the focus of the thesis and in order to reach a greater depth, some actors involved in the electrification of heavy road transport have been excluded. The actors included are those with an interconnected relationship and with a direct relation to the customer (i.e. local haulage contractors, local electrical grid owners, the local port authority, truck manufacturers and charging infrastructure companies) and the customer itself (i.e. local goods owners or transport buyers). Actors further upstream the value chain of the truck manufacturers and the local electrical grid owners are excluded (i.e. battery manufacturers and large-scale electricity producers). Moreover, landowners and property owners are outside the scope of the thesis since the local actors in most cases own their land or property themselves.

1.7 Disposition

The remainder of the thesis is structured as follows:

Chapter 2 presents previous literature within the research areas of business models, business model innovation and ecosystems; and how the three research areas have been studied together, to outline the theoretical context of the thesis.

Chapter 3 presents how the business model, business model innovation and ecosystem concepts have been defined based on previous literature for the purpose of this thesis, and depicts the relationship between the three concepts.

Chapter 4 describes the methodology applied to generate the empirical findings of this thesis, consisting of a three-phase study process: 1) a pre-study phase, 2) a data collection phase and 3) a data analysis phase. Lastly, research quality and ethics are considered.

Chapter 5 depicts the empirical context of the studied case, explaining current developments within electric heavy road transport in Sweden as well as within the geographical region of E16 Borlänge - Gävle Hamn, followed by a brief description of the respective ecosystem actor groups represented in the thesis.

Chapter 6 presents the empirical findings of this thesis. First, perceived business model opportunities and potential roles in the transition to electric heavy road transport are presented. Second, perceived business model challenges and critical roles in the transition are presented. Third, how the ecosystem actors manage the perceived business model opportunities and challenges through business model innovation and by doing so enact a role in the transition, is analysed.

Chapter 7 discusses the empirical findings of this thesis in relation to previous literature. The varying perceptions of business model opportunities and challenges are discussed, as well as how the ecosystem actors innovate their business models in terms of what sub-components are changed and through which innovation approach. Followingly, managerial and theoretical implications are considered as well as limitations and future research.

Chapter 8 summarises and concludes the thesis with regards to how the actors of the studied ecosystem perceive the transition to electric heavy road transport in terms of business model opportunities and challenges, and in turn how the ecosystem actors manage the identified opportunities and challenges through business model innovation, in effect participating in ecosystem development.

2. Literature Review

This chapter presents previous literature within the research areas of business models, business model innovation and ecosystems; and how the three research areas have been studied together, to outline the theoretical context of the thesis.

2.1 Business Models and its Innovation

The term "business model" has been applied in numerous studies and articles within recent years. Zott et al. (2011) performed an extensive literature study with the purpose of identifying different approaches to study the business model, in order to facilitate the extension of previous studies for future researchers and thus promote cumulative progress of the research area. The issue stems from varying definitions and research applications of the business model, where some studies even completely lack a definition of the studied phenomena (Ibid.). Massa et al. (2017: 73) provided one prominent and general definition of the term: *"a business model is a description of an organisation and how that organisation functions in achieving its goals"*. However, when moving beyond the general level, the definitions and applications of the business model within management theory often contradict each other or only partially overlap (Zott et al. 2011; Alt & Zimmermann, 2001). The business model research area has been met with critique, a lot of which relates to the issues mentioned above, but also more specific criticism arguing that the business model concept could cause "faulty thinking" (Porter, 2001) or that the term "model" is in itself inconclusive, causing assorted interpretations (Doganova & Eyquem-Renault 2009). Despite this, the business model design has been proven to be an important factor for profitability within some contexts (e.g. Chesbrough & Rosenbloom, 2002) and there are obvious company examples, such as Google, Airbnb & IKEA.

The rise of new improved business models also inspires and sometimes forces incumbent companies to re-shape their current business models, and while new technologies are introduced rapidly, the business model research has been focusing exceedingly on business model innovation (BMI) (e.g. Bolton & Hannon, 2016; Clauss, 2017; Foss & Saebi, 2017). The outline of one's business model could be arranged so that it promotes innovative developments, but the actual business model could also be innovated itself (Zott et al. 2011), providing a vast research area.

The business model innovation theory has been applied to analyse many different contexts, for instance how incumbent firms manage technological shifts, examined by Bohnsack et al. (2014) by using the passenger electric vehicle sector as a case. On a similar notion, Bolton & Hannon (2016) used a combined heat and power case to examine sustainability transitions through business model innovation. Both studies gave implications to BMI in regards to technology and sustainability developments, and the effect that path dependency within firms' business models could have. One interesting notion is that business models reaching success often are shared between actors or even competitors, due to the need to create legitimacy and network effects of the emergent technology benefiting all actors (Bohnsack et al. 2014). Moreover, scholars are arguing that in order for most technological transitions to realise, firms must align their business models with the disruptive technology. "*It is a business model problem, not a* *technology problem*" as argued by Christensen (2006: 48). Tongur & Engwall (2014) also shed light on the "business model dilemma of technology shifts", arguing that companies need to manage both technological innovation and business model innovation simultaneously in order to manage technological shifts effectively, such as the transition to electric heavy road transport.

2.2 Ecosystems

The "ecosystem" concept originates from biology, but has been considered being applied for the first time in management literature by Moore (1993), who suggested that a company needs to be viewed as a member of a cross-industry business ecosystem which includes suppliers, customers, competitors and other stakeholders, as opposed to a single industry. According to Moore (1993: 76), the common denominator for business ecosystems is the process of co-evolution, described as the "complex interplay between competitive and cooperative business strategies" supporting new products and the satisfaction of customer needs.

Following Moore (1993), numerous ecosystem definitions have been proposed, with two of the more prominent ones originating from Adner (2017) and Jacobides (2018). On the one hand, Adner (2017: 40) defines an ecosystem as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialise". The definition thus takes the value proposition as a starting point, and aims to identify the group of actors which need to interact and undertake the activities required to materialise the proposition (Ibid.). On the other hand, Jacobides (2018: 2264) suggests an ecosystem being defined as "a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled". The two definitions are similar, with commonalities being a group of partners or actors with multilateral relationships, but where Adner's definition is centred around the interaction enabling a central value proposition, Jacobides' definition is centred around complementarities and the absence of hierarchical control.

Not only does the literature propose different definitions of an ecosystem, there are also different types of ecosystems, such as "business ecosystems" (e.g. Moore, 1993; Clarysse et al., 2014), "innovation ecosystems" (e.g. Gomes et al., 2018) and "knowledge ecosystems" (e.g. Clarysse et al., 2014), which in turn are defined and applied differently. Gomes et al. (2018) argue that the business ecosystem and innovation ecosystem concepts have been used interchangeably in literature, but suggest that business ecosystems mainly relate to value capture whereas innovation ecosystems mainly relate to value creation. Adner (2006: 2) defines the innovation ecosystem as "the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution". Clarysee et al. (2014) highlight the differences between knowledge and business ecosystems, and suggest that the primary activity of knowledge ecosystems is generation of new knowledge, as opposed to business ecosystems where the focus is on generation of customer value. The electric heavy road transport ecosystem could arguably be defined somewhere at the intersection of these three ecosystem types, as value creation, value capture and knowledge generation activities are carried out by the ecosystem actors, to enable the offering of electric heavy road transport services to the transport buyer.

The extant ecosystem literature within management research has in addition to presenting numerous definitions of ecosystems and numerous types of ecosystems, approached the studying of ecosystems differently and done so within varying contexts. Among others, Ansari et al. (2016) studied the disruptor's dilemma of gaining the support of the incumbents their innovation disrupts within the U.S. television ecosystem; Hannah & Eisenhardt (2018) examined how firms navigate nascent ecosystems over time within the U.S. residential solar industry; Masucci et al. (2020) explored how technological bottlenecks within business ecosystems can be removed through open innovation within the oil and gas industry; and Dedehayir et al. (2018) studied the enactment of prominent roles during innovation ecosystem birth. However, business model innovation in ecosystems has not been extensively researched, and especially not within an electric heavy road transport context.

2.3 Business Model Innovation in Ecosystems

Previous literature combining the two concepts above is limited. Rong et al. (2018) did however find the intersection of the two concepts worth exploring, as their research examined the relationship between business model dynamics and business ecosystems within the 3D printing industry. The researchers suggested that the business ecosystem forms the context in which the business model develops and that the business ecosystem itself evolves to support the business model development. Hence, the relevant business ecosystem(s) must be taken into consideration when investigating business model dynamics, which previous research has failed to do (Ibid.). On a similar note, in a future research agenda for the study of business models by Zott & Amit (2013), it was suggested that research at the intersection of business models and ecosystems could be inspired by the insight that firms with different business models can share the same ecosystem, and a key question worth addressing was how firms adapt their business models to an evolving ecosystem. Accordingly, it is of interest to study the interrelationship between ecosystem development and business model innovation, especially within the emerging electric heavy road transport context.

3. Conceptual Framework

This chapter presents how the business model, business model innovation and ecosystem concepts have been defined based on previous literature for the purpose of this thesis, and depicts the relationship between the three concepts.

3.1 Definition of Concepts

Due to varying definitions of concepts applied in this thesis as demonstrated in the above literature review (e.g. Zott et al., 2011 or Massa et al., 2017), it is essential to clearly define the studied phenomenon to avoid misinterpretation and to clarify what has been studied. Here follows a definition of the three main concepts applied.

3.1.1 Business Model

The business model describes an organisation and how it achieves its goals (Massa et al., 2017). Through a positivist perspective, it is an attribute of a firm, with a real impact on business operations and relates to how a firm does business (Ibid.). The business model constitutes three building blocks, namely *value proposition*, *value creation* and *value capture* (e.g. Doganova & Eyquem-Renault, 2009, Clauss, 2017 or Tongur & Engwall, 2014).

First, *value proposition* relates to the value embedded in the product or service offering of the firm (Doganova & Eyquem-Renault, 2009). It relates to what the firm can offer its customer to satisfy its need and due to value being subjective and determined by the customer, the customer itself is of great importance to the value proposition. The customer markets served, the channels through which value is delivered as well as the relationship with the customer are all important factors of the value proposition of the firm (Clauss, 2017).

Second, *value creation* relates to the internal capabilities of the firm, such as its core competencies and its leadership, as well as the technologies and equipment applied to create value (Lepak et al., 2007). Internal processes and structures constitute the architecture of how people, technologies and activities are interconnected and how they combine to create value. In addition, the firm can leverage external resources in its value creation through partnerships or a value network.

Third, *value capture* translates the two above building blocks into revenue and cost (Doganova & Eyquem-Renault, 2009). It relates to how the firm charges its customer for the created value and thus how the firm retains the value offered to the customer (Tongur & Engwall, 2014).

3.1.2 Business Model Innovation

A change in one of the above building blocks is defined as business model innovation (Clauss, 2017). Similar to the business model concept, the business model innovation concept also constitutes three components, namely *value proposition innovation*, *value creation innovation* and *value capture innovation*.

First, *value proposition innovation* entails new offerings through development of new products or services; new customers or markets through redefining existing markets or entering new markets; new channels in terms of e.g. online or offline; and new or deeper customer relationships (Clauss, 2017).

Second, *value creation innovation* implies acquiring new internal capabilities to manage opportunities and challenges in the external environment; new technologies or equipment which can e.g. enable a new digital offering; new processes or structures for how technologies and capabilities are combined; and new partnerships to create value which the firm would not be able to create on its own (Clauss, 2017).

Third, *value capture innovation* entails new revenue models through e.g. leasing to generate continuous cash flows over time instead of a single cash flow at the point of sale; and new cost structures by e.g. lowering costs to be able to offer a low-price product to the customer (Clauss, 2017).

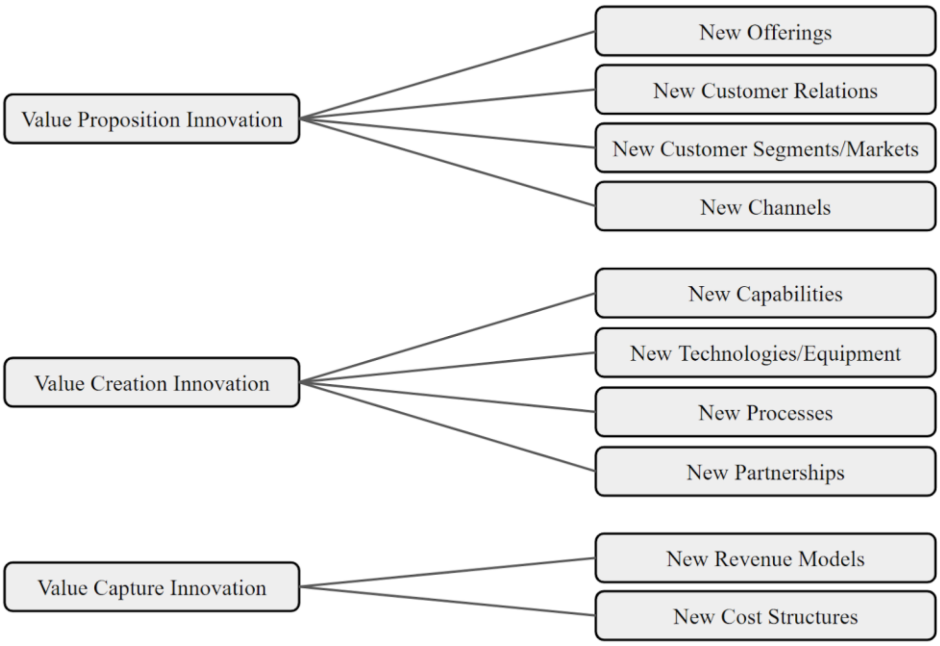


Figure 1: Components and sub-components of business model innovation. Adopted from Clauss, 2017.

In addition, the approach to business model innovation differs. On the one hand, business model innovation may be carried out *reactively*, to align or adapt to a change in current market conditions. On the other hand, business model innovation may be carried out *proactively*, to disrupt current market conditions, driven either by internal or external factors (Saebi et al., 2017). In contrast to the two business model innovation approaches, an *inactive* approach may be exhibited, implying no change to the business model.

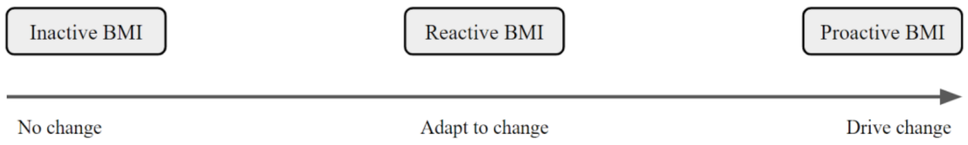


Figure 2: Illustrates the three approaches to business model innovation. Adopted from Saebi et al., 2017.

3.1.3 Ecosystem

A firm is a member of an ecosystem of actors which are interconnected and where each actor is to varying degrees important to the value proposition, value creation and value capture activities of the other actors of the ecosystem. As such, the performance of the business model of each individual actor is dependent on the performance of the business models of the other actors within the ecosystem. Together, the ecosystem actors combine their individual products and services to a customer-facing solution (Adner, 2006). Due to the multilateral nature of relationships within the ecosystem, the ecosystem concept differs from the bilateral nature of relationships of the value chain concept (Adner, 2017). Ecosystem members include stakeholders such as suppliers, customers, competitors and other complementors, who co-evolve through cooperation and competition in parallel (Moore, 1993). The ecosystem consists of actors engaging in commercial activity in a market with commercially available technologies, implying that the ecosystem is centred around how each complementary technology should be applied together and the innovation of such combinations, rather than being centred around the innovation of each respective technology (Gomes et al., 2018). The technological offering of one actor is complementary to the technological offering of another actor and by combining technologies, value to the customer can be created. In addition, competition between actors drives the improvement of technologies as well as business models. During the development of an ecosystem, actors may enact different roles which in turn can change over time (Dedehayir et al., 2018).

3.2 The Relationship Between Concepts

Apart from providing clear definitions of concepts applied, it is important to ensure an understanding for the interlinkage between these concepts from the perspective of the researchers who have authored this thesis. Here follows a description of the relationship between the three concepts presented above.

The interconnected actors of an ecosystem each apply their own business model, including a value proposition and a set of activities to create and capture this proposed value. By doing so, the ecosystem actor enacts a certain role. Each ecosystem actor has its own perception of internal and external opportunities and challenges, which can be managed through business model innovation, either proactively or reactively. Through a change in market conditions due to e.g. a change in consumer preferences or new legislation, the ecosystem actors may develop one or several components of their business models (i.e. reactive business model innovation). The ecosystem actors may also develop one or several components of their business models in order to disrupt current market conditions (i.e. proactive business model innovation). Due to the interdependence between ecosystem actors, other ecosystem actors may choose, if deemed necessary, to develop their business models to adapt to the new conditions of the ecosystem. Through this reconfiguration of business models of the ecosystem actors, a re-aligned ecosystem emerges which can satisfy the needs of the customer with regards to the new market conditions. The emergent ecosystem may or may not include a change in the roles enacted by the ecosystem actors, implying that e.g. a financier or a builder role in the emergent ecosystem can be enacted by the same ecosystem actor as in the previous ecosystem, or by a new ecosystem actor. The above description is illustrated in Figure 3 below.

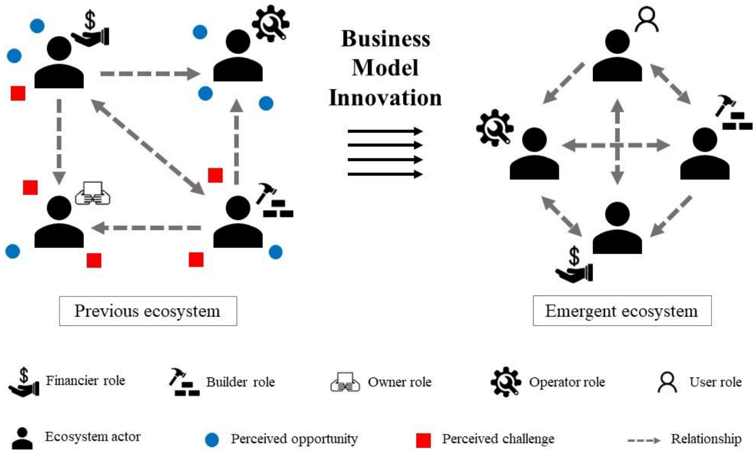


Figure 3: Illustrates how ecosystem actors manage perceived opportunities and challenges through business model innovation, resulting in the emergence of a re-aligned ecosystem with potentially new role enactments.

As regards the electric heavy road transport ecosystem specifically, there are roles relating to critical activities and technical components considered integral for the ecosystem to be able to offer electric heavy road transport services to the transport buyer (RISE, 2021). The activities include financing, building, owning, operating and using, and the technical components include electric heavy trucks, charging infrastructure, electrical grid infrastructure and local electricity production and storage. The pairing of the five activities and four technical components results in twenty roles which must be present in the electric heavy road transport ecosystem, e.g. electric heavy truck financiers and charging infrastructure owners. The roles (i.e. activity-technical component pairs) are found in the 4x5 matrix in Figure 4 below.

Technical components/ activities	Finance	Build	Own	Operate	Use
Electric heavy trucks	1	2	3	4	5
Charging infrastructure	6	7	8	9	10
Electrical grid infrastructure	11	12	13	14	15
Electricity production/storage	16	17	18	19	20

Figure 4: The matrix of roles integral to the electric heavy road transport ecosystem. Adopted from RISE, 2021.

4. Methodology

This chapter presents the methodology applied to generate the empirical findings of this thesis, consisting of a three-phase study process: 1) a pre-study phase, 2) a data collection phase and 3) a data analysis phase. Lastly, research quality and ethics are considered.

4.1 Research Approach and the Three-Phase Study Process

The research approach has been exploratory and abductive and with a cross-sectional case study as the chosen strategy. The methodology of the study can be divided into three different phases, consisting of a pre-study phase, an empirical data collection phase and lastly a data analysis phase, as demonstrated in Figure 5 below. The pre-study phase consisted of both first and second order data collection gathered from digital seminars, conferences and exploratory interviews with industry experts. The data collection phase consisted of qualitative data gathered through semi-structured interviews, which served well when a complex phenomenon was studied with the objective to gain insights from different actors (Yin, 1994; Saunders et al., 2015). A short questionnaire was also sent out prior to the interviews, to enrich the data and prepare the interviewees. Finally, this data was transcribed and analysed thematically during the third phase of data analysis. The abductive process of moving from data to theory during the pre-study phase and back to data during the data collection phase allowed for theory re-formulation as more data was collected, and the research process was not strictly sequential as the three phases to a certain extent progressed in parallel. This suited the exploratory approach of the thesis as it provided flexibility when new insights were reached and thus allowed for adaptiveness as more data was gathered during the research process (Saunders et al., 2015).

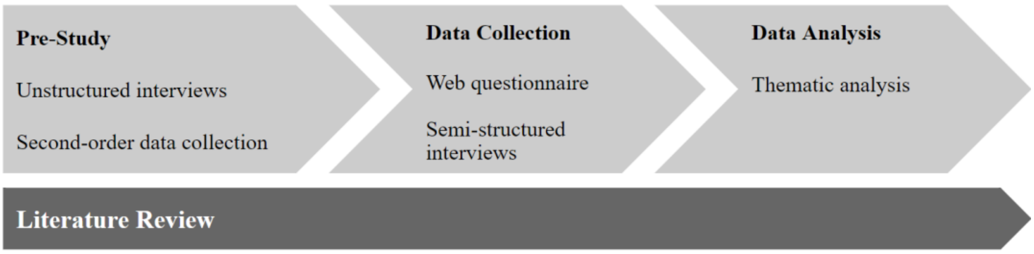


Figure 5: Illustrates the three phases of the study process of the thesis.

The three phases were all related to the studied case, i.e. the electrification of heavy road transport along E16 Borlänge - Gävle Hamn in Sweden. The local port (i.e. Gävle Hamn) was used as a starting point from which relevant local goods owners with relationship to the port were identified. Based on these goods owners, other actors considered relevant to the electrification of heavy road transport, i.e. local haulage contractors, local electrical grid owners, truck manufacturers and charging infrastructure companies, were identified and contacted to participate in the study. Building the case this way delimited the study to actors involved in the transportation of goods by road from the industrial sites to the port, and vice versa. Due to the large number of actors involved in the electrification of heavy road transport and the complexity this brings, a case study approach was considered beneficial since it allowed several different actors to provide their own perspective (Yin, 1994).

4.2 First Phase: Pre-Study

The aim of the pre-study phase was twofold, partly to get familiarised with the studied area, both in broad terms regarding the electrification of heavy road transport in Sweden but also more specifically connected to the studied case, and partly to formulate a theoretical foundation by reviewing existing literature. Attending a conference with the theme "Sustainable Transport Strengthens the Industry" and a seminar about electrical power supply, both with geographical connection to the case, provided information about current efforts towards electrification but also allowed for identification of potential actors to include in the data collection phase. This material was also strengthened and expanded by four unstructured and exploratory interviews with industry experts currently or previously engaged in road transport electrification projects, who provided valuable insights to the study. The material gathered within the pre-study was also used in order to formulate interview questions used in the data collection phase. The last pre-study interview was conducted with two individuals at Gävle Hamn with knowledge about current road transport flows in the area to make sure that the industries and haulage contractors identified were transporting goods to and from the port. The interview was also followed up with more data on transport quantities as well as information regarding which haulage contractor provided transport services to the respective goods owners. Apart from the first order data collected from the interviews, second order data was collected from reports, previous studies and projects relating to the case.

Table 1: Details of the conducted pre-study interviews and activities.

Activity	Source	Company/Initiative	Date	Purpose/Takeaways
Meeting	Senior Advisor	Siemens AB	2021-12-06	- Input to the research design - Second order data sources
Digital conference	"Sustainable Transport Strengthens the Industry"	Multiple participating actors, managed and initiated by Mellansvenska handelskammaren	2021-12-19	- Current developments - Identification of potential study participants
Meeting	Senior Advisor	Siemens AB	2022-01-26	- Contact information - General input
Interview	Senior Advisor	Truck Manufacturing Company	2022-01-27	- General input
Seminar	"Electrical Power Supply"	Multiple participating actors, managed and initiated by The Gävleborg Region, The County Administrative Board and the University of Gävle	2022-01-28	- Current challenges and initiatives - Identification of potential study participants
Interview	Senior Advisor	The Swedish Transport Administration	2022-01-31	- General input
Interview	Project representatives	Project REEL	2022-02-04	- Case examples - General input
Interview	Two C-Level Executives	Port Authority	2022-02-08	- Contact information - Data of traffic flows

The literature review was initiated during the pre-study phase and extended through the data collection and analysis phases. Since adopting an abductive approach, the theory was studied iteratively, moving back and forth between theory and empirical data (Saunders et al., 2015). The literature study was performed semi-systematically in the Web of Science database, starting with two separate search queries for “business model*” and “ecosystem*” in the titles of the published articles. The search was delimited to articles published in high quality business and management journals listed in the appendix (CABS, 2021) and restricted to highly cited articles, which generated a total of 41 articles. The abstracts of these articles were then examined which led to 15 being identified as irrelevant and thus excluded before the remaining 26 articles were reviewed in detail. The initial search was also extended in order to find articles exploring the combination of business model (innovation) and ecosystem theory, by performing combined searches of these terms and removing the highly cited constraint to increase the number of resulting articles. Reading the articles enabled further exclusions but also provided more interesting studies to include by following some of the references, also known as “backwards snowballing” (Wohlin, 2014). The research gap identified from the literature review in combination with the unstructured pre-study interviews generated a preliminary formulation of the research questions of the thesis.

4.3 Second Phase: Data Collection

Once a solid theoretical and practical understanding of the research area had been established and companies relevant to the studied case including potential interviewees had been identified, contact with representatives of these companies was initiated. Contact details had been gathered during the pre-study phase and the representatives were contacted via email where the study was introduced and interview participation was requested. The format and general content of the interview was provided to ensure transparency and promote credibility of the study, as well as to ensure that the interview participant of each company would be able to answer the interview questions. Business model knowledge was considered critical as well as insight into future plans or strategies related to the electrification of heavy road transport. This implied interviewing different roles at the studied ecosystem actors, e.g. the CEOs of the haulage contractors as compared to the logistics managers of the goods owners. Details of the conducted interviews can be found in Table 2.

Table 2: Details of the conducted semi-structured interviews during the data-collection phase.

Interview number	Role	Company	Abbreviation	Date	Duration
1	Business Manager E-Mobility	Charging Infrastructure Company 1	CIC1	2022-03-02	60 min
2	Head of Innovation	Electrical Grid Owner 1	EGO1	2022-03-03	60 min
3	Energy Program Manager	Goods Owner 1	GO1	2022-03-03	60 min
4	CEO	Haulage Contractor 1	HC1	2022-03-15	90 min
5	Supply Chain Manager, Technical Manager & Strategic Procurement Manager (3 interviewees)	Goods Owner 2	GO2	2022-03-16	60 min
6	Road Logistics Manager Europe	Goods Owner 3	GO3	2022-03-18	60 min
7	Head of Electrical Grid	Electrical Grid Owner 2	EGO2	2022-03-18	70 min
8	C-Level Executive	Port Authority	PA	2022-03-21	50 min
9	Charging Strategy and Business Development Manager	Truck Manufacturer 1	TM1	2022-03-22	60 min
10	Head of Global Logistics	Goods Owner 4	GO4	2022-03-22	55 min
11	Logistics Manager	Goods Owner 5	GO5	2022-03-23	75 min
12	CEO	Charging Infrastructure Company 2	CIC2	2022-03-25	45 min
13	Director Electromobility Business Development	Truck Manufacturer 2	TM2	2022-03-28	60 min
14	Head of Operations & Head of Sustainability (2 interviewees)	Haulage Contractor 2	HC2	2022-04-04	50 min
15	Head of Electrical Grid	Electrical Grid Owner 3	EGO3	2022-04-08	60 min
16	Project Manager (former CEO) & Quality and Environmental Coordinator (2 interviewees)	Haulage Contractor 3	HC3	2022-04-11	50 min

Following the consent to participate in the study, the interviewee received a web questionnaire regarding the company's current and future role in the electrification of heavy road transport. The focus of the questionnaire was the 4x5 matrix presented in Figure 4 in Chapter 3 of this thesis, with activities and technical components critical to the transition to electric heavy road transport, inspired by a sub-report on business, ownership and investment models from the Research & Innovation Platform for Electric

Road Systems (RISE, 2021). The questions related to where the company of the interviewee positioned itself today and where it might position itself in the future, including a short motivation. The five activities and four technical components were clearly defined to avoid misinterpretation and the definitions can be found in the appendix of this thesis. The interviewee was given ample time to complete the questionnaire and had to do so at least a week prior to the interview, so that the interviewers could review the questionnaire response from the interviewee, as this partly served as a basis for discussion during the semi-structured interviews.

Semi-structured interviews were deemed appropriate, as the interview type suited the exploratory and abductive research approach of the thesis (Saunders et al., 2015). Semi-structured interviews allowed for flexibility during the interview and gave the interviewers the possibility to probe answers from the interviewee when answers given were considered insufficient or of great significance for the research. The preliminary research questions formulated during the latter part of the pre-study phase were translated into key themes which resulted in the interview being divided into three parts. The first part concerned the current business model of the company where the interviewee was employed; the second part concerned business model related opportunities and challenges with the electrification of heavy road transport in the studied case; and the third part concerned the ecosystem enabling the electrification of heavy road transport in the studied case, current and future roles within this ecosystem as well as interaction among ecosystem actors. The web questionnaire response served as a basis for discussion during the third part of the interview. If the questionnaire had not been completed prior to the interview, the matrix in Figure 4 in Chapter 3 of this thesis was displayed to serve as a basis for discussion during the interview. Each part of the interview contained several open-ended questions which were adapted to which actor perspective the interviewee represented, as differences between actors implied somewhat different questions had to be answered. The open-ended questions were followed by probing questions adjusted to the answers of the interviewee. The general interview questionnaire can be found in the appendix.

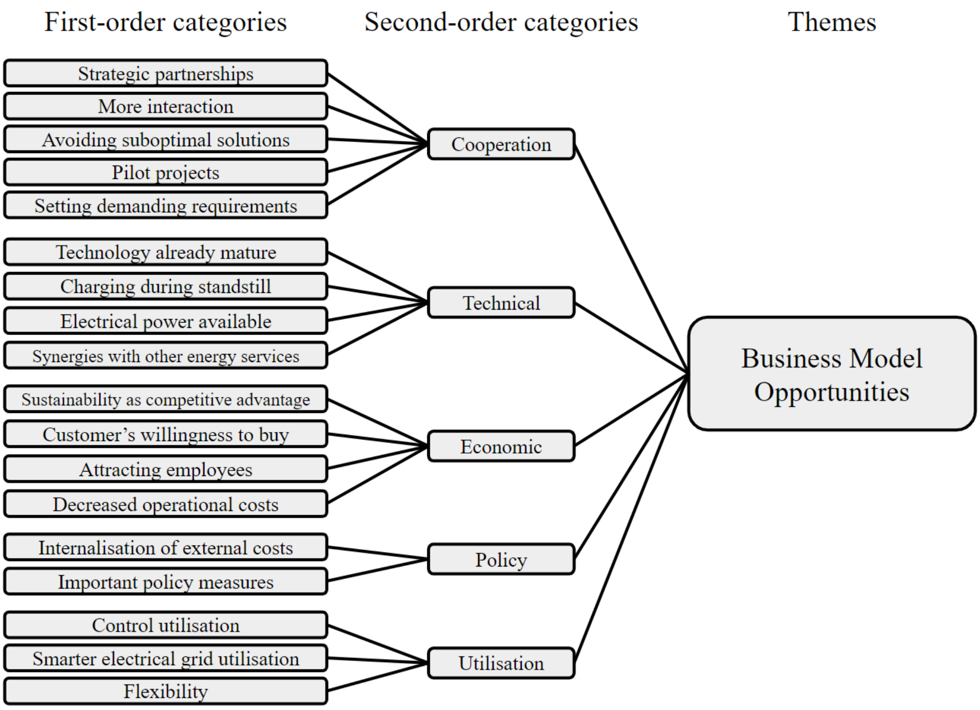
All interviews were conducted through online conferencing tools and recorded with the consent of the interviewee. The interviews were held in Swedish, all quotes presented in this thesis were thus translated to English. Directly following each interview, the interviewers separately took notes of how the interview had gone and of initial thoughts on the interview's contribution towards answering the research questions, followed by a brief discussion to compare thoughts.

In addition to the interviews, supportive data was collected during the two-day electric commercial vehicle fair *eComExpo* which was attended in person. Similar actors as those included in the interview study participated in seminars and discussions, where the themes largely overlapped with the research subject of this thesis. Meticulous notes were taken during the seminars. This allowed for triangulation and affirmation of earlier findings produced during the interview study.

4.4 Third Phase: Data Analysis

As soon as possible following each interview, the recorded audio file was transcribed manually and in detail to include every question and every answer of the interview. The transcription file was also finally checked for errors by listening through the recorded audio file. Notes were taken while transcribing and while checking for errors, in order to capture initial interesting thoughts about the data.

The computer-assisted qualitative data analysis software MAXQDA was used to code, structure and thematically analyse the transcribed interview material. To follow the exploratory nature of the study, the transcribed material was scanned in full to find and code relevant segments relating to perceived business model challenges, business model opportunities or business model innovation, which were pre-decided themes originating from the research questions. This led to a high number of coded segments consisting of a great number of different codes. The created codes were then checked to find similarities in order to group several coded segments into common first-order categories. These were then bundled into a second-order category and finally into a theme. The first- and second-order categories within the business model opportunities and challenges themes were constructed exploratory and derived from the initial coding. The categories within the business model innovation theme were instead derived from literature in order to capture relevant sub-components as described in *Chapter 3.1.2 Business Model Innovation* of this thesis. The final first- and second-order categories used to aggregate common perceptions within the interview data can be found in Figure 6 below.



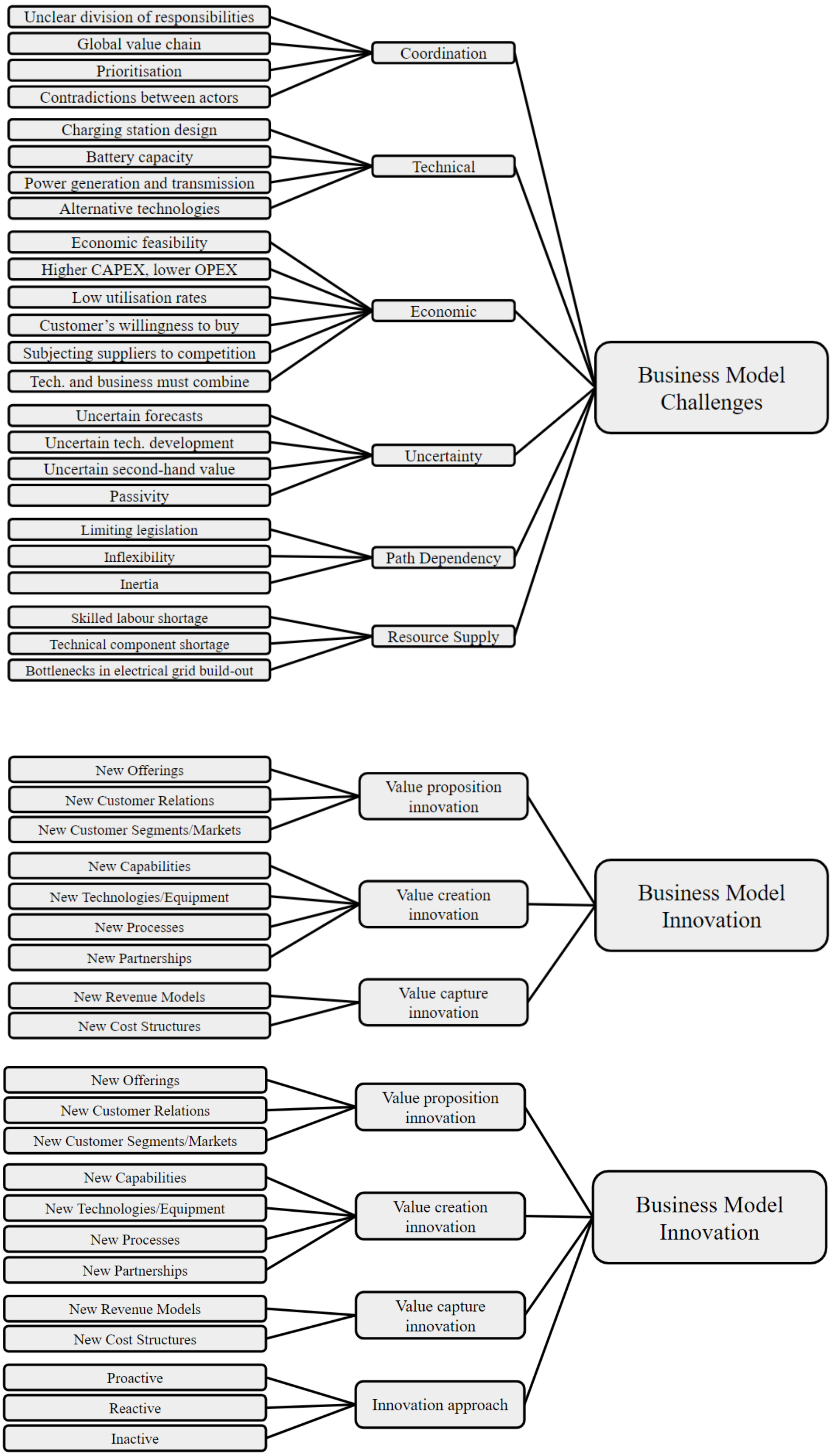


Figure 6: Displays the coding structure from MAXQDA with first-order categories aggregated to second-order categories and second-order categories aggregated into themes.

4.5 Research Quality

Various measures were taken to ensure the research quality regarding internal and external validity, reliability and objectivity. These terms have been further developed by Shah and Corley (2006) to better capture various methods that could ensure the trustworthiness of qualitative studies specifically, namely credibility, transferability, dependability and confirmability.

While the main data source was semi-structured interviews, data from other sources were gathered in order to triangulate the findings. The fair *eComExpo* as well as other secondary data sources were used to confirm and strengthen the main results. Member checks were used to confirm the researchers' interpretations by sharing the findings with the interviewees, thus providing an opportunity to identify any misinterpretations which in such cases were corrected. Additionally, the answers from the web questionnaire were further discussed during the interviews in order to let respondents elaborate answers and to address any interpretation difficulties in order to increase credibility. The empirical context is presented in Chapter 5 and the research method including the involved processes has been thoroughly described above within this chapter to enhance transferability. Further, the coding structure has been provided to show how the data analysis was performed, and codes with associated examples of evidence can be found in Table 3 and Table 4 in Chapter 6.

Purposive sampling was used to ensure enhanced dependability of the study. Sampling criteria were produced during the pre-study phase, where both responsibility of transport logistics and an expected insight into the company's business model and future plans were deemed to be important. The main theme of the research and what type of questions the interview would cover was explained when contacting the targeted employee. This was to give them the opportunity to forward the interview inquiry to a colleague, if they considered that someone else would be better suited for these types of questions. The confidentiality of the interviewees was also assured in order to let them speak more openly, since anonymity is likely to enhance the dependability of data (Saunders et. al., 2015).

Several measures were taken to ensure the confirmability of the study. Firstly, the objectivity of the second order data collection was enhanced by having both researchers reviewing it. The second order data was also gathered from various sources, both published in journals and grey literature. Secondly, objectivity and confirmability were also ensured with regards to the first order data by using accurate data management and recording, and through precise transcription of the interviews. Thirdly, all interview and contact data was documented to keep track of who had been contacted and provided with a web questionnaire, to enable follow up and to send out reminder emails if required. Careful notes of observations were also taken during the *eComExpo* fair to enable the researchers to go back and see what was said when and by whom.

4.6 Research Ethics

Research ethics is important throughout the research process (Saunders et al., 2015) and was considered in each of the three phases of the thesis. The purpose of the pre-study was for the researchers to gain a solid knowledge base of the subject matter, in order to design the study to achieve both practical and theoretical relevance and contributions. The pre-study interview questions were thus formulated to be able to fulfil this purpose, but ethical aspects were also considered. The questions were developed so that the interviewee could answer them openly and to avoid putting them in situations where answers could affect them negatively.

Similar to the pre-study, the primary data collection consisted of qualitative material gathered from interviews, which presented many ethical considerations as well. Before each interview began, the researchers clearly described the reason behind the study, how the gathered material was to be used as well as declared the researchers' company association. It was also communicated that participation was voluntary and that any question could be excluded or the entire interview could be ended by the interviewee, at any time and for any reason. To ensure privacy of the involved individuals, it was also communicated how the data would be anonymously presented, i.e. the interviewees role at actor group X. Consent to record the interview was finally checked and the interviewees were also invited to ask questions or raise concerns before the actual interview began, all to ensure informed consent before starting the interviews.

Research ethics was also considered during the data analysis and report writing phase, as it is crucial to uphold privacy, anonymity and confidentiality when analysing and reporting data (Saunders et. al., 2015). The interview recording and the transcribed files were stored in a safe and private cloud service. Coding of the interviews was done objectively to report the findings fully and accurately and details which could reveal the identity of the interviewee were excluded from citations and when presenting the result. Finally, the written draft results were distributed to all main interview participants, to ensure a correct interpretation of their responses collected during the interviews.

5. Empirical Context

This chapter depicts the empirical context of the studied case, explaining current developments within electric heavy road transport in Sweden as well as within the geographical region of E16 Borlänge - Gävle Hamn, followed by a brief description of the respective ecosystem actor groups represented in the thesis.

5.1 The Electrification of Heavy Road Transport in Sweden

The electrification of heavy road transport is still in its infancy in Sweden, as electric heavy trucks and the accompanying charging infrastructure have not reached commercial scale, even though such technical solutions are available on the market (ABB, n.d.; Scania, n.d.; Siemens, n.d.; Volvo Trucks, n.d.). However, electric heavy road transport has been extensively investigated as it is considered a viable option to decarbonise the Swedish heavy road transport sector (Fossil Free Sweden, 2020).

Less than a decade ago, electric road systems (ERS) was the main focus of electric road transport research and development projects. In 2013, The Swedish Transport Administration in collaboration with VINNOVA and The Swedish Energy Agency, initiated a pre-commercial procurement process for ERS demonstration facilities for heavy road transport (EU Supply, 2013). In 2015, The Swedish Transport Administration initiated the Electric Roads Programme (The Swedish Transport Administration, 2021b) and in the same year it was decided that two of the pre-commercial procurement participants, Region Gävleborg and eRoadArlanda, were to test two different ERS solutions until 2018 (Region Gävleborg, 2016). The two projects were the first ERS demonstration projects in the world (NCC, n.d.; Region Gävleborg, 2021).

In 2017, the Swedish Transport Administration submitted its National Roadmap for Electric Road Systems for the period 2018-2022 at the request of The Swedish Government (The Swedish Transport Administration, 2017). The roadmap highlighted the need for further investigation into stakeholders, business models and financing strategies; raising systems to higher technology readiness levels; implementing a major ERS pilot including payment and access systems; and creating a long-term plan for the construction and development of ERS in Sweden. In the years following the publication of the National Roadmap for Electric Road Systems, EY was assigned to support The Swedish Transport Administration in the analysis of ERS in five phases, resulting in the publication of five reports on different topics (The Swedish Transport Administration, n.d.-a).

The first three EY reports only concerned ERS, and more specifically business models and financing for the development of ERS (EY, 2018); roles, actor relations and risks in the ERS market (EY, 2019a); and the role of the operator, financial assessments and payment systems (EY, 2019b). In parallel, the project group of the Research and Innovation Platform for Electric Roads managed by RISE conducted its research during the period 2016 to 2020, which was divided into eight work packages, namely electricity supply; environmental impact; construction, operations and maintenance; architecture and business ecosystem; business impact and implementation strategies; access and payment systems;

standardisation; and knowledge spread (RISE, 2021). In June 2020, the Electric Roads Programme was renamed as the Programme for the Electrification of Heavy Road Traffic on the National Road Network, as The Swedish Transport Administration was now assigned to also investigate battery electric and hydrogen fuel cell technologies in combination with ERS, due to rapid technological development within these two areas (The Swedish Transport Administration, 2020). The final two reports from EY thus had a broadened scope to include stationary charging (EY, 2020) as well as hydrogen and fuel cell technologies (EY, 2021).

In October 2020, the Swedish Government proposed a number of measures to intensify the electrification of the transport sector (Government Offices of Sweden, 2020). The Swedish Transport Administration was assigned to plan for a build-out of ERS along state-owned roads and to analyse the need for charging infrastructure to accommodate fast charging of heavy trucks along larger roads. The Commission for Electrification was also appointed, led by the Swedish Minister of Transport and with members including representatives of the heavy road transport and the electricity sectors.

In 2021, The Commission for Electrification presented electrification pledges from 17 Swedish regions, with a total of 252 actors including private companies, universities and county administrative boards, with the mutual intention to accelerate the electrification of regional goods transport by road (Government Offices of Sweden, 2021). In the following year, the Swedish Government presented its National Electrification Strategy, including 67 measures to accelerate the electrification of society (Government Offices of Sweden, 2022a). Examples of measures directly relating to the electrification of the transport sector included realising smart charging of electric vehicles; enabling proactive development of the electrical grid to reduce lead times by half; an action program for charging infrastructure including a review of current policy instruments; and analysing the possibility to let electrical grid owners build out charging infrastructure during a limited time period (Government Offices of Sweden, 2022b).

5.2 The E16 Borlänge - Gävle Hamn Region

The industry cluster around Borlänge, Falun, Avesta and Gävle is characterised by industries with world-class export products, making it an important growth and welfare resource for Sweden. The international presence of these companies makes them dependent on The Port of Gävle of which through both inbound and outbound products passes daily. The transportation to and from the port relies to a large extent on heavy road bulk transport managed by local haulage contractors. With the high traffic volumes this creates, a part of the E16 road was used in order to conduct the world’s first ERS demonstration project (Region Gävleborg, 2021).

5.2.1 Electrification Within the Region

Apart from development at a national level, there are ongoing regional initiatives for sustainable transportation within the area today. During recent years, many industries have focused on increased sustainability connected to the production phase but are now starting to look beyond this to enable a decrease in value chain emissions as well. Mellansvenska Handelskammaren, a regional business organisation, believes that sustainable and cost-effective transportation have a direct effect on the competitiveness of the region. To accelerate the climate change mitigation of the transport sector, they are cooperating with regional industry and transportation companies. This includes participating in and organising conferences in order to bring actors together and promote collaboration and information sharing. More specifically, in collaboration with the involved companies and AFRY, they have developed an action plan consisting of 16 action points for increased transport efficiency (Mellansvenska Handelskammaren, 2022). Some are directly related to electrification, including the need for a regional electrification strategy, pilot projects for the electrification of heavy road transport and cooperation between the transport and energy sector - where the need for new business models and increased actor dialogue is highlighted. Other interesting action points relate to sustainable transportation as a customer offering, competence provision as well as more efficient permit processes and faster decision paths.

In 2016, two kilometres of existing road network between Sandviken and Kungsgården, a section of highway E16, was electrified with the aim to examine technical and economic aspects and to provide a knowledge base for national decisions on the electrification of transport (Region Gävleborg, 2021). The road was operational for four years before it was decommissioned, but the project was seen by some as a starting point to electrify the 12 kilometres from Borlänge to Gävle. Sundelin et al. (2017) conducted a pre-study of business ecosystems for electric roads at the request of The Swedish Transport Administration where, among other roads, the stretch between Borlänge and the port of Gävle was investigated. Using various approximations it was concluded that the electric road could become economically viable given certain traffic flows. The Swedish Transport Administration decided to progress from demonstration projects to a permanent electrified road, but in 2021 it was decided that this would be built between Örebro and Hallsberg, and not between Borlänge and Gävle which was one of the top five options (The Swedish Road Transportation, n.d.-b; The Swedish Road Transportation, 2019).

In May 2021, many actors within the industry, transportation, county administration and regional boards in Dalarna and Gävleborg Region signed a mutual electrification pledge with the intent to "collaborate purposefully to change the freight transport system in Dalarna and Gävleborg to electric drive and to apply for an electrification pilot with a focus on electrification of freight transport with hydrogen and batteries" (Government Offices of Sweden, 2021). Ongoing initiatives include an energy optimised port-cluster, run as a 10-year program by the port authority (Gävle Hamn, n.d.), and cooperation platforms initiated by Energiintelligent Dalarna (Energiintelligent Dalarna, n.d.) and Arena Elkraft Gävleborg (Region Gävleborg, 2022).

The Swedish Transport Administration expresses that the solutions to electrification of heavy road transport are evolving at a fast pace, including battery capacity and hydrogen fuel cell solutions. This leads to a slightly lower level of ambition when it comes to the development of electric roads (The Swedish Road Transportation, 2021a). Moreover, there are still a lot of uncertainties connected to regulations as well as socio-economic profitability of electric roads. "*Even if the investment costs are covered there is still a need for subsidies to achieve economically viable operations*" (Senior Advisor at The Swedish Transport Administration, 2022). As such, the different electrification technologies will continue to develop in parallel.

5.2.2 The Electric Heavy Road Transport Ecosystem Actors

The emerging electric heavy road transport ecosystem along E16 Borlänge - Gävle Hamn consists of numerous actors. The sixteen interviewees participating in this thesis represent different organisations within six ecosystem actor groups, namely goods owners, haulage contractors, the port authority, truck manufacturers, electrical grid owners and charging infrastructure companies. The first four are traditional transport ecosystem actors, the electrical grid owners are traditional electricity ecosystem actors and the charging infrastructure companies emerged as electric vehicles were introduced.

The five *goods owners* represented in this thesis, i.e. the transport buyers, are local companies operating within the mining, steel and pulp and paper industries on a global market. The three local *haulage contractors* perform transport services within various industries such as forestry and construction, and include two organisations which consist of a few hundred member organisations. The two *truck manufacturers* are global companies which are expanding their product portfolios to include electric heavy trucks. The local *port authority* is a municipal company which manages and develops the port area. Goods purchased on a global market are imported through the port and goods sold on a global market are exported through the port. The three local *electrical grid owners* are all responsible for the management of the local electrical grid within three smaller geographical regions within the studied ecosystem. The two *charging infrastructure companies* include one global supplier of charging infrastructure and one charging infrastructure project developer operating on the Swedish market.

6. Empirical Findings

This chapter presents the empirical findings of this thesis. First, perceived business model opportunities and potential roles in the transition to electric heavy road transport are presented. Second, perceived business model challenges and critical roles in the transition are presented. Third, how the ecosystem actors manage the perceived business model opportunities and challenges through business model innovation and by doing so enact a role in the transition, is analysed.

6.1 Business Model Opportunities and Potential Roles

This section presents the empirical findings relating to the first part of the first research question of this thesis, i.e. the business model opportunities with the transition to electric heavy road transport as perceived by the sixteen interviewees. These are categorised into opportunities relating to cooperation, technology, economics, policy and regulation, and utilisation. Followingly, the results of the web questionnaire are presented, regarding what roles the organisations of the interviewees could consider enacting in the future.

6.1.1 Cooperation Opportunities

Achieving electrification of heavy road transport relies to a great extent on increased interaction and cooperation among the ecosystem actors, something that was brought up during every interview. The type of interaction differs in terms of what is being done and what kind of cooperation that is inquired for. The development of new partnerships and initiation of pilot projects were requested, but also the formulation of distinct future plans and stricter requirements induced on each other. There was a need for increased dialogue and transparency to increase the understanding of the challenges that other actors were experiencing. Increased dialogue, especially at an early phase, was highlighted from the electrical grid owners' perspective, both during the interviews and the *eComExpo* fair (Interviews EGO1, EGO3; Viklund, 2022).

> *"Regardless of the type of business, where we have entered at an early stage and been invited into the process, it has worked so much easier and smoother for all parties (...) I think that the interaction, the close cooperation, is definitely a success factor for all parties and I think we have good preconditions but it can definitely become better."*

- Head of Electrical Grid at Electrical Grid Owner 3 (EGO3)

Foresight and co-planning were considered key in order for the electrical grid owners to keep up with the increased need for electric capacity (Interviews EGO1, EGO2, EGO3), and more cooperation was considered important as the energy and logistics system connected more tightly (Interviews TM1, TM2, CIC1, GO1, GO2, PA, HC1, HC2). More specifically, actors were more engaged in, and called for an increase of strategic partnerships as well as pilot projects:

"(...) that you work together with high transparency and that you work quite closely and iteratively while being humble, you are not going to be right from the first second, you have to test to get to the finish line. It applies to both them and us. And I mean you can not count on a 100% commercialization on the first project, not for anyone. But it is an investment case for everyone, and you do it because you want to get an output later on."

- Business Manager E-Mobility at Charging Infrastructure Company 1 (CIC1)

Pilot or demonstration projects in order to gain knowledge, display good examples and inspire others were requested (Interviews HC2, GO3, GO4, GO5, PA, CIC1). Other forms of cooperation or interaction such as tougher demands from progressive actors and the willingness to achieve change were both requested and showcased by the interviewees. The goods owners should demand change from the haulage contractors so that they in turn dare to make a change (Interview PA), and the ambitions to do so were expressed by all of the representatives of the goods owners (Interviews GO1, GO2, GO3, GO4, GO5). It was pointed out that the ones with larger capital flows must take bigger risks, make stricter demands and act to lower the risk for others:

"The haulage contractors are reserved, they do not have the same capital flow as a manufacturing industry, they do what the customer demands, so as a customer we must invite [the haulage contractors] for example through longer agreements."

- Logistics Manager at Goods Owner 5 (GO5)

"The haulage contractors do not drive the change, we do as our customers want. If customers want us to run on single malt whiskey, then we run on single malt whiskey. If they want us to run on electricity or biogas, RME, or HVO, then we do so."

- Project Manager (former CEO) at Haulage Contractor 3 (HC3)

It was underlined that the most effective way to induce change would be for the goods owners to demand fossil free flows and express the willingness to pay a premium price to achieve it (Interview PA). Several goods owners were already today endorsing more sustainable transport alternatives by accepting an extra expense for vehicles run on HVO and were experiencing an increased willingness from the end customer to pay for more sustainable solutions in relation to both the transportation and manufacturing process (Interviews GO1, GO2, GO3, GO4).

Another way of cooperating is through public statements that work to reduce uncertainties, which some actors were trying to achieve by expressing distinct goals or providing guarantee arrangements. The truck manufacturers were providing public future outlooks for the manufacturing of new heavy electric vehicles, which could reach 50% of total sales in 2030 (Interview TM2; Fossil Free Sweden, 2020), and participating in analyses and mapping of where new charging infrastructure should and will be built (Interview TM2). Other representatives of the truck manufacturers also expressed the importance of providing their plans for the buildout of charging infrastructure in order to reduce investment uncertainties for the haulage contractors (Berger, 2022). Another way of reducing this kind of uncertainty is by guaranteeing certain mileage or battery capacity and providing leasing alternatives (Interview HC3). Other actors were also trying to collaborate in order to reduce uncertainties by investing in charging infrastructure at their site (Interviews PA, GO4) or by guaranteeing transportation volumes through strategic partnerships (Interview GO4).

6.1.2 Technical Opportunities

The electrification of heavy road transport could entail a great number of technical opportunities, and local industry electrification synergies could be exploited. Opportunities with the fact that the electric trucks could be charged at low power and low costs overnight at their own site and recharged when loading or unloading in order to reach a higher system efficiency, were recognised (Interviews TM1, HC3, GO3). A majority of the technical conditions were already deemed to be available, as it was stated how the challenges were connected to policies and societal development rather than technical factors (Sandberg, 2022). This was highlighted with technical analyses conducted by the organisations of the interviewees:

"We have made careful simulations and calculations of environmental benefits and also if the technology works and we believe that this will work really well, they [the trucks] run during the day and can charge at night."

- CEO at Haulage Contractor 1 (HC1)

"(...) the products we have right now, they are fully possible to perform many assignments. Typically the case you are looking at, it is like 110-120 kilometres to the port (...) many cars here are heavier but 44 tons we have driven 350-360 kilometres or so on one charge. Of course it is reduced if you drive 74 tons, but to manage 200 kilometres is probably no major issue (...) If I remember correctly it was a 2h drive in one direction in this case, which means you still have to stop when you drive back and forth, then you can just as easily take the opportunity to charge."

- Director Electromobility Business Development at Truck Manufacturer 2 (TM2)

Another major technical component is the electrical grid that must provide enough capacity to enable charging power to the electric trucks. Some interviewees suggested that this was no issue for the majority of the geographical area focused on in this case:

"We have a fantastically strong electricity network, regional network in the area. There are challenges with that, but the power is there to connect such charging stations if we are talking heavy transport, no problem."

- Head of Electrical Grid at Electrical Grid Owner 3 (EGO3)

“The more we have looked at it the less worried we have become. Especially within the first years, there has been a lot of concern about this, ‘will we have enough power?’ or things like that. But as I said, we are in areas that generally have so much power anyway. So raising it by 5-10% is not the whole world. In addition, there are good systems for spreading the charge so that you do not charge everything at the same time and things like this.”

- Energy Programme Manager at Goods Owner 1 (GO1)

The opportunity to increase the technical flexibility of the grid by equipping more advanced sensors was also discussed, making it possible to utilise the grid closer to its safety margins without transcending them (Interview EGO1).

Opportunities relating to synergy effects were also expressed. It was underscored that much-earned experiences from the electrification of passenger cars easily could be transferred to heavy vehicles and that the processes and working models would be similar (Interview CIC2). On a similar note, the installation of fast charging stations for passenger cars within the industrial sites could ease the transition to electrified heavy transport at an early stage (Interview GO4). Other synergies were also mentioned in connection to local energy production and storage. The opportunity to achieve network effects where local energy production could serve as power-enhancing to the grid when needed and stored when not, which later could be used in order to charge the trucks, was highlighted:

“(...) it is quite easy for many of these players to choose to throw solar panels on their rather large depot roofs and poof - now they supply both electricity and power to the electricity grid and appear as relatively sustainable.”

- Charging Strategy and Business Development Manager at Truck Manufacturer 1 (TM1)

Energy storage solutions benefitting the entire electrical installation by combining it with one’s own electricity production or by having the ability to use a lower main fuse was also emphasised. This would also benefit the electrical grid since less power needs to be taken from it (Interview CIC2).

Lastly, some interviewees promoted the use of hydrogen technology and the synergy effects it could have in connection to electric heavy road transport. A goods owner representative expressed that they were building a hydrogen production plant mainly to replace fossil fuels within their production, but that synergies with transport could imply an expansion of the hydrogen production (Interview GO4). Hydrogen was also brought up as a potential storage solution in order to balance the electrical grid (Interview EGO2).

6.1.3 Economic Opportunities

The vast majority of the interviewees mentioned that sustainability is seen as a competitive advantage (Interviews GO1, GO2, GO3, GO4, GO5, TM1, HC1, HC2, HC3, PA, EGO3), both in relation to the goods owners' production but also in connection to emissions from transportation, which was gaining increased focus:

"They are leading the way, the goods owners in this region today, but they have perhaps traditionally worked mostly with sustainability within their sites and now it is time to take the next step and start working with it within the transport system as well."

- C-Level Executive at Port Authority (PA)

All of the interviewees representing the goods owners acknowledged that they had seen an increased demand and that their customers were willing to pay an extra premium for more sustainable products (Interviews GO1, GO2, GO3, GO4, GO5). Some were now hoping and predicting that the same will occur for the transportation of goods as well:

"(...:) that which we sell to those customers, that is fossil-free products, they expect over time that it will be fossil-free delivery as well. In that way, we have a very clear target image."

- Road Logistics Manager Europe at Goods Owner 3 (GO3)

"Our task in Sweden is to show that, if you take the climate into account, you have a much stronger product and then you become better than what the competitors are. (...) and the demand for a complete sustainable value chain is growing and has accelerated during the last two years."

- Head of Global Logistics at Goods Owner 4 (GO4)

All of the goods owner representatives were willing to accept a higher initial transportation cost for electrified heavy road transport (Interviews GO1, GO2, GO3, GO4, GO5) and it was mentioned that it will become the cheaper alternative in the foreseeable future (Interviews HC1, GO1, GO4, TM1). This was also prominent at the *eComExpo* fair where the need for the customers' willingness to pay the initially higher cost was highlighted. A seminar speaker stated that they currently had more than thirty agreements where the customer paid extra for sustainable transport (Reinholdsson, 2022). There were also perceived opportunities to optimise the transport logistics system, particularly related to the charging, in order to decrease operating costs which was seen as the key to making the electrification of heavy road transport an economically viable alternative (Interviews GO4, TM1). It was highlighted that the reference is a technology that has been around for hundred years, where costs have been steadily pushed down, making it unreasonable to compare with if the goal is to become emission-free:

"You can not compare with that if you have decided to become emission-free, there are cheaper alternatives and initially it will be more expensive. But people will be willing to pay for it."

- CEO at Haulage Contractor 1 (HC1)

It was also underscored how sustainable transportation is seen as a competitive advantage:

"I also know that we have taken market shares due to the fact that we have offered sustainable transport. (...) The board made a decision in 2009 that we should be at the forefront of the transition to sustainable road transport and that is still the way it is. And we do it because we believe that it is commercially good and because we want to do it in order to reduce our emissions."

- Project Manager (former CEO) at Haulage Contractor 3 (HC3)

Another competitive advantage affecting the profitability of the haulage contractors was the ability to attract drivers and counteract the driver shortage within the industry (Interviews HC2, GO3, GO5; Reinholdsson, 2022). Shifting to sustainable fuels and pursuing electrification of the vehicles, had made the haulage contractors experience an increased desire to drive for them (Interview HC2; Reinholdsson, 2022). Lastly, the electrification of heavy road transport was seen by the electrical grid owners as a substantial economic opportunity (Interview EGO2, EGO3). Using load control and flexibility for peak-shaving could provide a higher utilisation rate on the electrical grid and thus enable more income (Interview EGO3).

6.1.4 Policy and Regulation Opportunities

Several interviewees perceived opportunities relating to policy and regulations with regards to CO_2-emissions as well as other measures that have the potential to affect and accelerate the electrification of heavy road transport. By increasing the price on fossil-based fuels and the emissions those account for, through taxes or emissions trading systems, politicians set a clear direction that will enable the transition (Interviews PA, GO2, TM2, HC1). Internalising the external costs was perceived as a necessity to make fossil-based transport services too expensive to continue with (Interviews PA, TM2).

But there were also other regulations that could potentially ease the shift to electric heavy road transport. The representatives of the electrical grid owners all mentioned how a change in current legislation could create an opportunity to improve their working processes (Interviews EGO1, EGO2, EGO3). This subject was also treated at the *eComExpo* fair, where practitioners mentioned how it would be favourable for electrical grid owners to be able to develop the grid based on forecasts (Mörnstam, 2022; Pettersson, 2022; Tullgren, 2022). On another note, the Mobility Package from the EU was mentioned (Interview GO5; European Commission, n.d.), a set of rules primarily instituted to safeguard social aspects of the transport sector, but implications from these rules would also affect electrification. Stricter regulations would hopefully offset some of the barriers connected to a global value chain when it comes to electrification of heavy road transport in Sweden (Interview GO5). Moreover, there were perceived opportunities to change the weight and length regulations to facilitate the transition to heavy battery electric vehicles until technology improvements can enable production of more energy-dense batteries (Interviews GO4, HC2, CIC1; Brååt, 2022).

6.1.5 Utilisation Opportunities

The electrification of heavy road transport uncovers several opportunities relating to flexibility and consumption patterns, mainly linked to how the electrical grid is utilised. The interviewees representing the local electrical grid owners all perceived opportunities to actively manage the consumption through dynamic pricing or changes in the grid tariff system (Interviews EGO1, EGO2, EGO3):

"(...) then you want to control and you start to influence things with tariffs and things like that, it will perhaps appear built-in functions in the tariff so that it takes into account power and time."

- Head of Electrical Grid at Electrical Grid Owner 2 (EGO2)

"I think that, based on the situation we are in, the state of the electrical grid, it is desirable that you can have an impact on the charging infrastructure and an impact on electricity production and storage. (...) To be able to give signals for, and the desire for a change. (...) we want to be able to say - if you continue to use it now then it will be very expensive, or if you can produce right now, we can pay a lot for it, or more for it at least. (...) through business models and control signals, both technical and business control signals, have the ability to affect the others."

- Head of Innovation at Electrical Grid Owner 1 (EGO1)

It was believed that increased flexibility would provide opportunities for the electrical grid owners to avoid large and costly grid extensions (Interviews EGO1, EGO2, EGO3). The main issue was not technical constraints, but rather that the change was occurring much faster than the grid could be expanded (Interview EGO1). Flexibility was also related to the time sensitivity of the goods owners. It was stated how the acceptance of longer lead times from the goods owners or transport buyers would provide a great opportunity to enable more dynamic charging (Interviews EGO1, GO4, GO5; Reinholdsson, 2022; Berger, 2022). One of the goods owner representatives mentioned how this opportunity could be manageable:

"On the other hand, there may be challenges in how you arrange a transport, you may have to rethink that part, i.e. that you may have to waive transit time by a few days if it is to be fully electrified, as it looks today, or something similar. But I would say that that is no worse than manageable, if you can prove the upside of it."

- Head of Global Logistics at Goods Owner 4 (GO4)

It was highlighted how the transition to electric heavy road transport is fully viable by enabling and utilising flexibility (Viklund, 2022). If the transport sector itself refrain from being more flexible, it might be possible to increase flexibility by integrating storage solutions with charging stations which could even out the load on the electrical grid (Interviews EGO1, CIC2) or that other local industries could provide flexibility in order to speed up the transition to electric heavy road transport (Interview

EGO1). The opportunity of using the electrical grid more effectively and increasing the full-load hours in order to make the charging of the trucks a more viable business was emphasised:

"The local networks, those that are at 400 volts and 10 kilovolts, it is said that it uses about 10-15% of the capacity. This full load hours that I am talking about, if you can increase it in some way through smarter energy use then the cost for society and for electricity network customers will be much lower. (...) so the key is to improve capacity utilisation and increase what is called full-load time."

- Charging Strategy and Business Development Manager at Truck Manufacturer 1 (TM1)

6.1.6 Potential Roles in the Transition to Electric Heavy Road Transport

In addition to perceived business model opportunities, Figure 7 below presents the responses at an aggregated ecosystem level to the web questionnaire regarding which roles the organisation of the interviewee could consider enacting in the future, which were further explicated and discussed during the interviews. The figure illustrates that all of the roles inquired about could potentially be enacted by the organisations within the studied ecosystem, as there was no role which did not receive an answer. The dark blue colour in the finance-column and the use-column imply that these two activities could potentially be carried out by the greatest number of organisations, whereas the build-column and the own-column received the least number of answers as shown by the light blue colour, indicating that these two activities could potentially be carried out by the lowest number of organisations. Further, the dark blue colour in the charging infrastructure-row indicates that activities relating to this technical component could potentially be carried out by the greatest number of organisations, whereas the electrical grid infrastructure-row and the electricity production/storage-row received the least number of answers as shown by the light blue colour, indicating that activities relating to these two technical components could potentially be carried out by the lowest number of organisations. A greater number of answers is not necessarily beneficial, as it could imply coordination difficulties if several actors were to share a certain role.

Figure 7: A heat map illustrating web questionnaire and interview responses at an aggregated ecosystem level regarding potential future roles in the electric heavy road transport ecosystem. A darker blue colour implies a greater number of answers, whereas a white colour would imply no answer.

Additionally, in Figure 8 below, responses from the web questionnaire and interviews on an ecosystem actor group level are presented, with one heat map per ecosystem actor group represented in the study. First, as shown in the goods owners' heat map, the goods owners could consider financing and using all of the technical components and carry out all charging infrastructure-related activities excluding building. Second, as shown in the electrical grid owners' heat map, the electrical grid owners will most likely continue with their current operations, i.e. financing, building, owning and operating electrical grid infrastructure, but could also consider to carry out activities relating to charging infrastructure and electricity production and storage, if there were to be changes to current legislation. Third, the truck manufacturers' heat map illustrates that the truck manufacturers could potentially finance, build, own and operate both electric heavy trucks and charging infrastructure. Fourth, the port authority's heat map demonstrates that the port authority could consider financing, owning and operating charging infrastructure and electricity production and storage, as well as carrying out all activities related to electrical grid infrastructure, as the port authority representative expressed that they would continue to manage the electrical grid infrastructure at the port site. Fifth, as illustrated in the haulage contractors' heat map, the haulage contractors could consider carrying out all activities (excluding building) with regards to electric heavy trucks and charging infrastructure. Finally, the heat map of the charging infrastructure companies indicates that these could potentially carry out all activities relating to charging infrastructure as well as all activities (excluding using) relating to electricity production and storage.

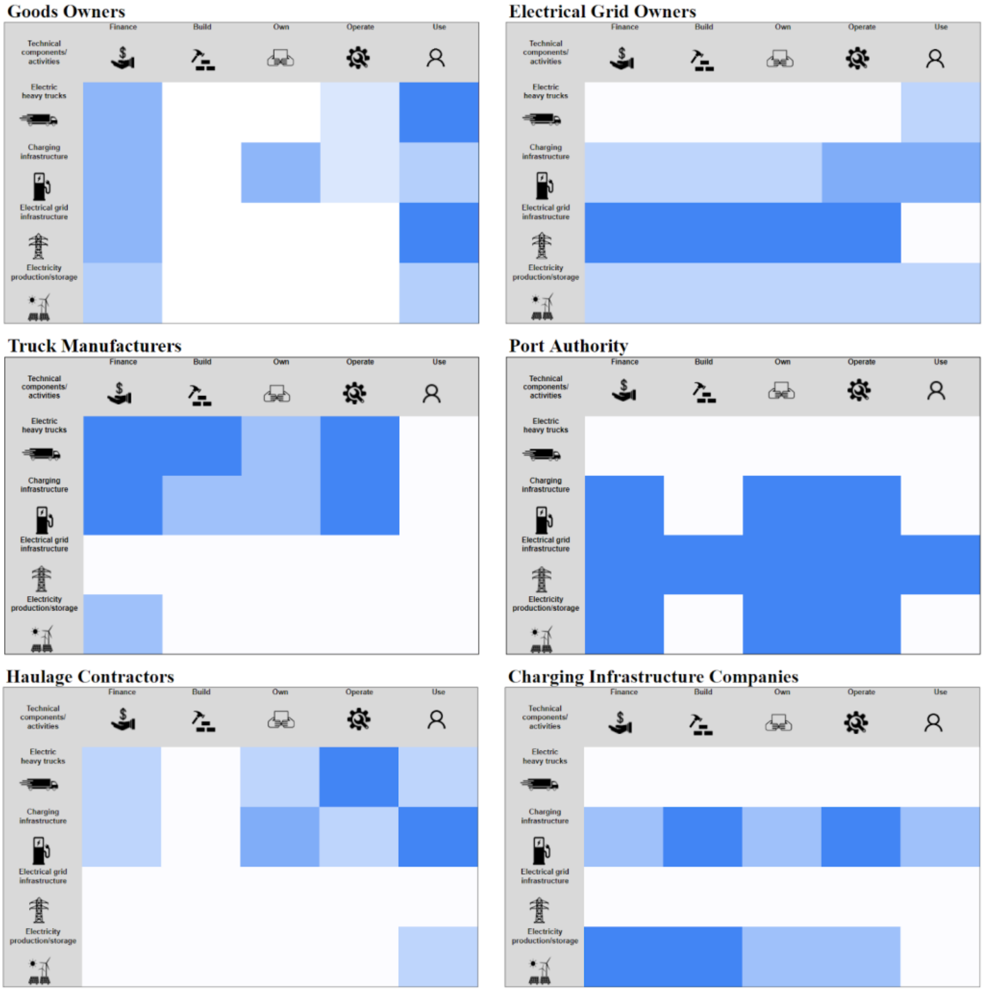


Figure 8: Six heat maps illustrating web questionnaire and interview responses at an ecosystem actor group level regarding potential future roles in the electric heavy road transport ecosystem. A darker blue colour implies a greater number of answers, whereas a white colour implies no answer.

6.1.7 Summary

As indicated by the above findings, the ecosystem actors perceived a range of different business model opportunities with the transition to electric heavy road transport, and within each opportunity category there were differences in what each actor and actor group highlighted. The more prominent opportunity categories related to cooperation, technical and economic opportunities, as they were reported by the greatest number of different actor groups. Cooperation opportunities related to e.g. tighter integration due to the merging of the electricity and transport ecosystems as well as strategic partnerships. Technical opportunities related to e.g. energy storage and local electricity production to facilitate charging infrastructure and to counteract electrical grid congestion. Economic opportunities related to e.g. increased demand for a sustainable value chain and with that the competitive advantage of being able to provide sustainable transport services. Business model opportunities as perceived by the ecosystem actor groups with examples of evidence are summarised in Table 3 below to provide an overview.

As regards potential future roles in the transition to electric heavy road transport, all of the roles inquired about could potentially be enacted by one or several of the ecosystem actors, implying that the ecosystem actors should jointly be able to transition to electric heavy road transport. A great number of ecosystem actors could consider financing and using the different technical components, and a great number of ecosystem actors could consider carrying out activities relating to the charging infrastructure, which may entail coordination challenges. As demonstrated in the ecosystem actor group-specific matrices in Figure 8, the ecosystem actor groups will in general continue enacting their traditional roles, but some actor groups will also enact new roles. For example, the truck manufacturers will expand their role by potentially carrying out activities relating to the charging infrastructure in addition to their traditional role with activities relating to the electric heavy trucks.

Table 3: Business model opportunities as perceived by the ecosystem actor groups with examples of evidence.

Opportunities	Charging Infrastructure Company	Electrical Grid Owner	Goods Owner	Port Authority	Truck Manufacturer	Haulage Contractor
Cooperation	We want to have very in-depth discussions in order to deliver as good a product as possible, we are interested in getting all the data from the customer and an understanding of what they do and what they want to do	Where we have entered at an early stage and been invited into the process, it has worked so much easier and smoother for all parties. I think that the interaction, the close cooperation, is definitely a success factor for all parties	As a customer we must invite the haulage contractors for example through longer agreements	We will have to collaborate more tightly and in a different way than we might have done compared to before when the market took care of all this itself	We are experiencing more and new collaborations, and it will continue and become even more. It is a tighter connection between the energy system and the logistics system and it requires tighter cooperation	We do as our customers want. If customers want us to run on single malt whiskey, then we run on single malt whiskey. If they want us to run on electricity or biogas, RME, or HVO, then we do so
Technical	I think you should see energy storage as something for your entire electrical system, not just for chargers. If you can produce your own electricity you can store it in your batteries and recharge them at low power, then when needed you can mash out all this power at the same time. Without having to take it from the electrical grid	We have a fantastically strong electricity network, regional network in the area. There are challenges with that, but the power is there to connect such charging stations if we are talking heavy transport, no problem	We are in areas that generally have so much power anyway. So raising it by 5-10% is not the whole world. In addition, there are good systems for spreading the charge so that you do not charge everything at the same time and things like this	Alternatively, we can find complementary ways to supply the vehicles with electricity from either local production or via battery swapping or however you want to do it, there might be other opportunities if you do not have enough power in the grid	The products we have right now, they are fully possible to perform many assignments, typically the case you are looking at	We have made careful simulations and calculations of environmental benefits and also if the technology works and we believe that this will work really well
Economic		At the same time this is a huge business opportunity, we can hopefully use load control and flexibility to even out power peaks in a very good way and get an utilisation rate on our electricity network and of course get more revenue, so that it is a fantastic opportunity	The demand for a complete sustainable value chain is growing and has accelerated during the last two years	The opportunity is that we manage to change the freight transport system. That is like the big profit that you can see, and that we thereby contribute to that the goods owners in the region can get a sustainable value chain that makes their offer to the market even stronger	Understanding the concept of full load hours and optimising it will be the key to making the charging business as economical as possible and keeping operating costs as low as possible	I also know that we have taken market shares due to the fact that we have offered sustainable transport. We do it because we believe that it is commercially good and because we want to do it in order to reduce our emissions
Policy			The best way to drive development towards environmentally friendly transport is to raise taxes on fuel. And it will come, there is reason to believe that it will be, since all parties want this	I think that there should be a direct demand from somewhere and a very clear direction politically that leads to acting	The policies are what controls it in the end. If we get an ETS for heavy vehicles that are implemented, it will be easier, then carbon dioxide-intensive transport will be more expensive, and then it will be more interesting with the alternatives	I think that the electric trucks must have different regulations regarding the total weight, that an electric truck may weigh 100 tons so that you still can have the same gross load weight. So you do not have to halve the load just because you have batteries with you too
Utilisation		We want to be able to say - if you continue to use it now then it will be very expensive, or if you can produce right now, we can pay a lot for it, or more for it at least. Through business models and control signals, both technical and business control signals, have the ability to affect the others	You may have to rethink how you arrange a transport, i.e. that you may have to waive transit time by a few days if it is to be fully electrified, as it looks today, or something similar. But I would say that that is no worse than manageable, if you can prove the upside of it		If you can increase the full load hours in some way through smarter energy use then the cost for society and for electricity network customers will be much lower	

6.2 Business Model Challenges and Critical Roles

This section presents the empirical findings relating to the second part of the first research question of this thesis, i.e. the business model challenges with the transition to electric heavy road transport as perceived by the sixteen interviewees. These are categorised into challenges relating to coordination, technology, economics, uncertainty, path dependency and resource supply. Followingly, the results of the web questionnaire are presented, regarding what roles the interviewees considered critical in the transition.

6.2.1 Coordination Challenges

According to the conducted interviews, coordinating activities within the ecosystem was considered a difficulty, especially when it is currently unclear how responsibilities are to be divided (Interviews EGO3, EGO1, PA, TM1, GO5, GO2, GO1). Uncertainty regarding who should invest in, own and pay for the charging infrastructure was expressed, and particularly public charging infrastructure as it will have many users (Interviews GO1, GO2, GO5). If there is shared ownership of charging infrastructure, there will be a matter of prioritisation of who gets to use the infrastructure and at what times (Interviews GO4, GO1). One of the goods owners stated that they will build and operate the charging infrastructure themselves and at their own industrial sites to avoid these issues (Interview GO1). Additionally, it was indicated that coordination will be increasingly difficult as there are many new parties which have not previously interacted, as the energy system and the logistics system becomes increasingly intertwined:

"(...) there are many parties who will have to find new roles and cooperate with each other which have traditionally not cooperated. Representatives of the energy system (...) and the logistics system have not actively worked together previously."

- C-Level Executive at Port Authority (PA)

As the ecosystem expands, there will also be more contradictions between actors (Interviews CIC1, TM2, GO3, GO4). Every actor might not experience an appealing business case on its own, but there is a net gain at a system level (Mörnstam, 2022). Thus, it will be difficult to prioritise between the different actors' objectives:

"(...) it comes with challenges that there will be more stakeholders and more compromising, so it might in one way become more difficult to do business."

- Business Manager E-Mobility at Charging Infrastructure Company 1 (CIC1)

"There will be contradictions, there will be trade-offs and so on. It is not always going to be great fun for any of these [stakeholders], there will be winners and there will be losers."

- Head of Global Logistics at Goods Owner 4 (GO4)

Not only will prioritisation be required within the electric heavy road transport ecosystem, there will also be increased competition for electricity from other sectors which are electrifying, where there will have to be prioritisation between ecosystems and sectors (Interviews EGO2, GO5, TM2). Further, all of the local goods owners represented during the interviews serve a global market. Hence, there were perceived challenges with coordinating a global value chain (Interviews GO2, GO3, GO4, GO5). An inability to affect haulage contractors in markets outside of Sweden through strict sustainability requirements was expressed, as these markets were not as advanced sustainability-wise as Sweden. In addition, many of the haulage contractors performing services in Sweden are international companies, implying that it was difficult to even affect the haulage contractors within Sweden (Interview GO3). It was also underscored that transitioning to electric heavy road transport is not even favourable if electricity production is not fossil-free, which is the case in many countries besides Sweden (Interview GO4; IEA, 2021d).

6.2.2 Technical Challenges

The electric heavy road transport ecosystem relies on a stable supply of electricity to function, which the traditional heavy road transport ecosystem does not. As such, many of the interviewees perceived electrical power transmission and generation constraints as one of the greater technical challenges to the electrification of heavy road transport, due to the great power needs of the electric heavy trucks (Interviews EGO3, EGO2, PA, TM2, HC3, HC1, GO5). Multiple speakers at *eComExpo* also mentioned how the power constraints in the electrical grid were considered a system bottleneck (Holmér, 2022; Sandberg, 2022). According to one of the interviewees, it will be difficult to replace entire diesel truck fleets with an electric equivalent:

"(...) it is an enormous challenge to charge 80 trucks with 850 kWh [of battery capacity] overnight. We are talking about a smaller Swedish town which we will need to build-out a transformer for."

\- Project Leader (Former CEO) at Haulage Contractor 3 (HC3)

This is especially true when the local industrial sector is being electrified and due to the potential establishment of large power-consuming server halls in the region, which will have to compete with the development of charging infrastructure for available electrical power (Interviews EGO2, HC1).

Inadequate capacity of current batteries was perceived as another great technical challenge to the transition (Interviews EGO2, CIC1, HC3, HC2, GO3). The batteries are still too heavy and too expensive, which in turn has a hindering effect on the demand for charging infrastructure (Interview CIC1). Moreover, heavy and large batteries will negatively affect the amount of load each truck can carry. Thus, if the number of trucks must increase, the environmental impact mitigation might be lost (Interview HC2). The 64-tonne trucks required for some industrial transportation needs are not even commercially available currently (Interview HC2; Volvo Trucks, n.d.; Scania, n.d.).

In addition to power generation and transmission constraints and inadequate battery capacity, the importance of designing the charging stations to avoid damage to the equipment and to enable multiple trucks of large size to charge simultaneously to avoid congestion was underscored (Interviews CIC2, TM2, HC3, HC2). Further, due to the haulage contractors being highly constricted by current driving time and rest period regulations, it was considered imperative that charging will not further increase expensive standstill of the trucks (Interviews GO3, CIC1).

Not only were there perceived challenges with current electrification technologies, but also with having to choose between electrification technologies. A need to test and compare different technologies such as battery electric vehicles and hydrogen fuel cell vehicles was indicated, as the two technologies might be better suited for different applications (Interviews TM2, HC1, GO1). The importance of reviewing different technologies as they are continuously developed was further highlighted:

"(...) but if you do not evaluate what can be driven with battery electric today because you think there will be another solution in the future, then that is something which is a hindrance."

- Director Electromobility Business Development at Truck Manufacturer 2 (TM2)

Lastly, the few interviewees who mentioned electric road systems emphasised challenges such as high cost, inadequate traffic intensity in Sweden for electric road systems to be profitable and the requirement of co-financing (Interviews HC1, GO1).

6.2.3 Economic Challenges

Apart from the local electrical grid owners and the port authority, all of the interviewees represent private companies which engage in commercial activity. Thus, almost all of the interviewees highlighted the issue of economic feasibility and that it was a challenge with the transition to electric heavy road transport (Interviews EGO3, CIC1, CIC2, TM1, TM2, HC1, HC3, GO1, GO2, GO3, GO4, GO5). The challenge with the electric trucks currently being more expensive than an equivalent diesel truck was underlined, especially with regards to the initial investment (Interviews HC1, GO3, GO2). Although the operational costs of the electric trucks are lower, the total cost of ownership is still higher (Interview HC3, GO3). This was a critical challenge especially for the haulage contractors as they operate in a financially vulnerable industry:

"In the end it is about a haulage contractor feeling that this is an economically acceptable investment, I think that is extremely important."

- Road Logistics Manager Europe at Goods Owner 3 (GO3)

In addition to the electric truck investment needing to be economically feasible, so does the charging infrastructure investment. A low utilisation rate has a negative impact on the profitability of a charging infrastructure investment. When the power ratings of the chargers increase, the cost increases and it will not be possible to build many chargers which are to be used only now and then, as is the case to some extent with passenger EVs (Interview TM2). Low utilisation rates are especially apparent in the countryside and in other low traffic intensity areas (Interviews CIC2, EGO1). A challenge closely related to economic feasibility was the customer's willingness to buy. The goods owner needs to be willing to buy a sustainable transport service from the haulage contractor (Interview PA) and the customer needs to be willing to pay a premium for sustainably transported goods (Interview GO2). Due to the business-to-business nature of the local goods owners' business relations, the end consumer has a relation with a company further down the value chain, implying that sustainability requirements of the end consumer does not have as large an effect as compared to a business-to-consumer market (Interviews GO2, GO5). Another economic challenge was that technology and business need to go hand in hand. If something is technically possible, it does not necessarily mean it should be done:

"(...) you need to separate what is technically possible and what is economically feasible. Just because it is possible it does not mean it should be done. (...) That is exactly what I have been rambling on about, to focus on what is financially sustainable in the long run, not listen to the tech geeks. What is technically possible is not relevant."

- Energy Program Manager at Goods Owner 1 (GO1)

Lastly, several of the representatives of the goods owners highlighted the importance of subjecting their suppliers to competition to ensure supplier independence (Interview GO1, GO2, GO5). The buyer wants to avoid a supplier monopoly, which could become the case if the buyer were to set too high sustainability requirements on transport services and there would only be one supplier able to meet the requirements (Interview GO2). In addition, supplier independence was a perceived challenge when it came to goods owners co-owning charging infrastructure with a haulage contractor, as there was a perceived risk that the two parties could become too dependent on each other (Interview GO5).

6.2.4 Uncertainty Challenges

Uncertainty about the future causes forecasting to become difficult (Interviews EGO3, EGO1, EGO2, TM2, GO3, GO4). The electrification of society is accelerating which makes it difficult to forecast when and where to reinforce the electrical grid (Interviews EGO1, EGO2, EGO3). Investment decisions also become more difficult when future yields are uncertain (Interview EGO2). It was stated that it is resource intensive to try to forecast the future, but predictability is important since charging an electric truck is time-consuming and when it might have to be coordinated with other players in the market (Interview TM2). Besides forecasts being uncertain, there were perceived challenges originating from an uncertain and accelerating technological development. With uncertainty in technological development, it is difficult to make investments in a given technology (Interview PA, TM2, HC3, GO5). The fast-moving technological development was expected to lead to many poor but learning-wise important investments in the near future:

"(...) we will, the whole industry, we will be burning through a great amount of learning money now and in three to four years look back and say, what were we thinking? Just because the technological development is so enormously fast-moving."

- Project Leader (Former CEO) at Haulage Contractor 3 (HC3)

Another challenge which is a consequence of uncertainty is passiveness. Multiple interviewees expressed that they experienced lack of activity from other actors as well as from their own organisation (Interviews EGO3, CIC2, PA, HC2, GO2). It was stated that this was due to actors being occupied with their daily operations and that they were awaiting political decisions and technological developments:

"I think the greatest challenge is that you have so much to do in your day-to-day that the most comfortable is to think 'business-as-usual' and wait for it to happen… that someone else does it or that it happens out there."

- C-Level Executive at Port Authority (PA)

In addition to uncertainty challenges relating to forecasting, technological development and passiveness, there were interviewees who reported uncertain second-hand value and technological lifetime of battery electric trucks as compared to an equivalent diesel truck as a challenge (Interviews HC3, GO5, GO1), which was also highlighted at the *eComExpo* fair (Reinholdsson, 2022; Brååt, 2022). This was in turn closely associated with the experienced passiveness and an unwillingness to invest.

6.2.5 Path Dependency Challenges

The transition to electric heavy road transport is progressing at a relatively slow pace due to inertia in the current system (Interviews EGO1, EGO3, TM2, HC3, GO1, GO4, GO5). It was described how it takes a great amount of time for suppliers to develop and launch new products, and that delays in the supply chain can have a severe impact (Interview GO1). One representative of the local electrical grid owners suggested that the inertia is due to long lead times in their processes, caused by time-consuming activities such as slow permission procedures, finding a well-suited technical solution, and dialogue with the Swedish Transport Administration and the County Administrative Board (Interview EGO3). Several speakers at *eComExpo* also highlighted the issue of long lead times and permit processes (Nordin, 2022; Holmér, 2022; Mörnstam, 2022; Pettersson, 2022). Additionally, one interviewee underlined this issue:

"Right now, when you ask the question to secure and increase the electrical power, then it takes five weeks before you get any feedback. Then it is another couple of months before you put the shovel to the ground. (...) When it comes to permits, the bureaucrats who work at the county administrative boards across the country have to roll up their sleeves and put some pressure on. Here we have an automotive industry transitioning, we have an industry transitioning, but the bureaucracy can not keep up, it takes too much time."

- Project Leader (Former CEO) at Haulage Contractor 3 (HC3)

It was proposed that this is mainly due to that change is accelerating, and that the current system can not keep up with the pace of the transition:

"It is not that we are electrifying the transport sector or electrifying heavy transport in itself, the problem is that it is happening so fast. (...) Given time, would there be any electrification which we could not handle? No, there is not. (...) The hindrance is that we are trying to do it so much faster than what the structures we have built until today have been suited for."

- Head of Innovation at Electrical Grid Owner 1 (EGO1)

Another challenge adding to the path dependency of the ecosystem was current legislation which limited what the electrical grid owners were allowed to do, since they operate in a monopoly market (Interviews EGO1, EGO2, EGO3). Current legislation does not allow the electrical grid owners to expand capacity in the grid and connect new customers based on forecasts of future demand. The electrical grid owners are also limited in how they are allowed to prioritise between new connections. Instead, the electrical grid can only be expanded when an actual request for connection has been submitted and on a first come first served basis (Interviews EGO2, EGO3). Moreover, current legislation does not allow the electrical grid owner to produce electricity, own energy storage or charging infrastructure (Interviews EGO1, EGO2). In addition to the electrical grid owners being limited by current legislation, the flexibility of the electrical grid is to a certain extent limited. It was expressed that an electrical grid which you can quickly add large connections to without the use of flexibility comes with a societal cost (Interview EGO1). Simultaneously, the electrical grid is built to be able to meet peak demand, which implies that a great amount of redundancy is built into the grid. One interviewee provided an analogy describing this issue:

"If the entire Swedish population were allowed to buy a ticket to the cinemas but there were no limitations to when they can use the ticket to watch a movie, meaning that everyone could go at the same time in the worst case, there would be many empty cinemas. That is sort of how the electrical grid is built."

- Charging Strategy and Business Development Manager at Truck Manufacturer 1 (TM1)

Besides there being on the one hand a great amount of redundancy built into the electrical grid and on the other hand a low level of flexibility, the current operations of the logistics system were in addition considered inflexible. A delayed or absent delivery of goods to a customer comes with great cost as there is mostly little buffer built into the logistics system, which could become an issue if an electric truck needs to stop to charge for a longer period of time due to a depleted battery (Interviews TM2, HC2).

6.2.6 Resource Supply Challenges

Several interviewees considered sourcing of both technical and human resources a challenge for the transition to electric heavy road transport. The interviewees reported a shortage of a wide range of competencies, among others certified electricians to install and maintain the charging infrastructure; automotive technicians with skills within operation and maintenance of electrical truck engines; software developers; electrical grid planners and project leaders to enable operation and development of the electrical grid; and administrators dealing with concession permit requests (Interviews CIC2, TM1, HC3). The large power needs for the charging of the electric trucks adds to the complexity:

"It is not just to replace an engine heater pole, it requires extensive work with transformer stations and electricity contracts and such, power control which needs to be calculated very meticulously, so of course there will be a lot with regards to that. But that is a challenge I have to say, to get a hold of all this competence, everyone within power electronics and the electricity business is screaming for people and competence."

- CEO at Charging Infrastructure Company 2 (CIC2)

In addition, uptime requirements for the charging infrastructure were considered much stricter when it comes to commercial goods transport as compared to the passenger vehicle sector:

"A truck that does not charge in the morning is toast, you will have no earnings that day. Which both results in loss of revenue but could also result in penalties if you have promised to transport something and you can not perform your duty. So there is a completely different uptime requirement."

- Director Electromobility Business Development at Truck Manufacturer 2 (TM2)

This entails a much greater demand for electricians servicing the charging infrastructure (Interview TM2). To meet the growing demand for skilled workers, both new workers will be required, and parts of the current workforce will need to be re-skilled (Interview TM1; Falkstrand, 2022). In addition to the shortage of competence required to transition to electric heavy road transport, the traditional heavy road transport ecosystem experienced a shortage of truck drivers, which will have a negative impact on an electric heavy road transport ecosystem as well (Interview GO2). In terms of technical components, the issue with sourcing semiconductors was reported as well as long lead times for the production of large power transformer stations (Interviews TM1, EGO3).

6.2.7 Critical Roles in the Transition to Electric Heavy Road Transport

In addition to perceived business model challenges, Figure 9 below demonstrates the most critical roles with the transition to an electric heavy road transport ecosystem according to the interviewees, aggregated to an ecosystem level. As indicated by the heat map, the supply side was considered challenging, i.e. to finance and build the technical components. Specifically, the building of electrical grid infrastructure was considered a critical role, as it received the greatest number of answers from the interviewees and from all the different ecosystem actor groups represented in the study. Moreover, the charging infrastructure was considered as the technical component with the greatest number of critical roles, as responses implied challenges relating to all activities excluding its usage.

Figure 9: A heat map illustrating interview responses at an aggregated ecosystem level regarding the most critical roles with the transition to an electric heavy road transport ecosystem. A darker red colour implies a greater number of answers, whereas a white colour implies no answer.

Moreover, Figure 10 below illustrates responses from the interviews on an ecosystem actor group level, with one heat map per ecosystem actor group represented in the study. First, as demonstrated in the goods owners' heat map, the financing of the electric heavy trucks and the charging infrastructure were considered the most critical roles in the transition, according to the representatives of the goods owners. Second, the electrical grid owners' heat map indicates that the most critical role in the transition was considered being the building of electrical grid infrastructure. Third, as illustrated in the truck manufacturers' heat map, the truck manufacturer representatives considered the most critical roles being the building of electrical grid infrastructure and the operation of charging infrastructure. Fourth, the port authority considered the financing of electric heavy trucks as well as the building of electrical grid infrastructure and electricity production and storage as the most critical roles. Fifth, as illustrated by the haulage contractors' heat map, the most critical role in the transition was considered being the building of charging infrastructure. Lastly, the charging infrastructure company representatives considered the building of charging infrastructure being the most critical role in the transition to electric heavy road transport.

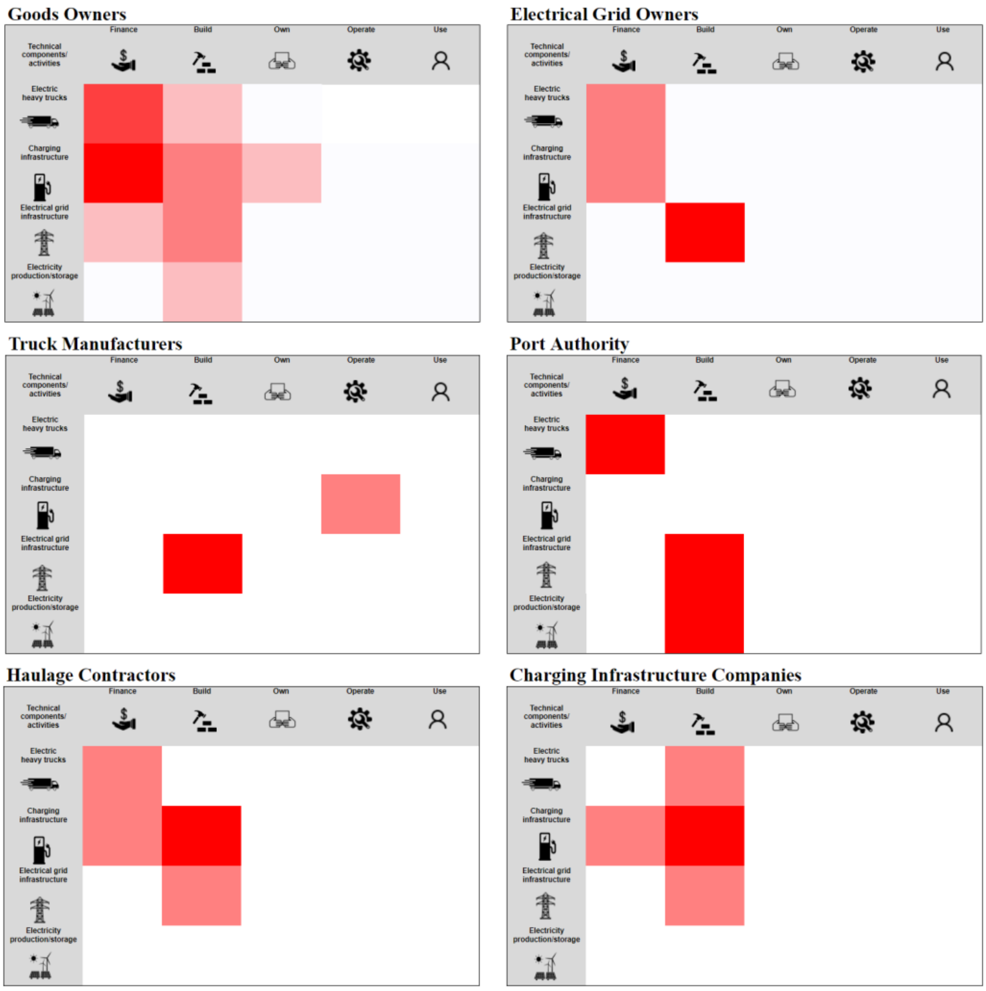


Figure 10: Six heat maps illustrating interview responses at an ecosystem actor group level regarding critical roles in the transition to an electric heavy road transport ecosystem. A darker red colour implies a greater number of answers, whereas a white colour implies no answer.

6.2.8 Summary

As demonstrated above, a great variety of perceived business model challenges were identified within the studied ecosystem. Economic feasibility was one of the greatest challenges perceived by the ecosystem actors, since the interviewees represent companies wanting to make profitable investments. A great number of the interviewees perceived coordination challenges arising parallel to opportunities with increased cooperation, as there will be parties who have previously not interacted and an increased number of stakeholders. In contrast to the perceived technical opportunities, current technology was also considered a challenge, for instance due to the great power needs of the electric trucks and due to the high load requirements for certain industrial applications. Several interviewees representing different ecosystem actor groups expressed an uncertainty of the future, leading to passiveness among ecosystem actors. Business model challenges as perceived by the ecosystem actor groups with examples of evidence are summarised in Table 4 below to provide an overview.

Moreover, as regards critical roles in the transition to electric heavy road transport, the most critical role was in general considered being the building of electrical grid infrastructure, as many of the interviewees expressed that this was a national issue arising from the electrification of a wide range of sectors. Activities relating to the charging infrastructure were also considered being critical to the transition. Interestingly, the truck manufacturers did not consider activities relating to the electric trucks as critical, implying that this technical component should not be an issue once the charging infrastructure has been built out. With reference to the matrix of potential roles in Figure 7, a great number of actors could consider carrying out activities relating to the charging infrastructure, why there does not seem to be a shortage of actors to manage the critical roles relating to this technical component. However, there may arise coordination challenges relating to who does what, when and how, and possibly competition among actors as there are multiple interested parties. Another interesting remark is that it was mainly the goods owners, the haulage contractors and the port authority, i.e. the traditional customers of the truck manufacturers and the charging infrastructure companies, who perceived the financing of electric trucks and charging infrastructure as critical roles. This is something which the truck manufacturers and the charging infrastructure companies must bear in mind when transitioning to an electric heavy road transport ecosystem, as it is the customer who will in the end pay for the technical components.

Table 4: Business model challenges as perceived by the ecosystem actor groups with examples of evidence.

Challenges	Charging Infrastructure Company	Electrical Grid Owner	Goods Owner	Port Authority	Truck Manufacturer	Haulage Contractor
Coordination	It comes with challenges that there will be more stakeholders and more compromising, so it might in one way become more difficult to do business	Difficulties arise when there is no clear definition of responsibilities and who fixes an issue when it occurs	There will be contradictions, there will be trade-offs and so on. It is not always going to be great fun for any of the stakeholders, there will be winners and there will be losers	There are many parties who will have to find new roles and cooperate with each other which have traditionally not cooperated	There is a tighter integration with a system which we have less control of. There is demand for electricity from a range of different sectors such as the industry and households.	
Technical	The batteries are too heavy and too expensive	The large power need is a challenge to us. How do we technically supply that power?	We work with extremely heavy goods in our world, and trucks meeting such load requirements are not commercially available	There has to be power at the right place and at the right time	If you do not evaluate what can be driven with battery electric today because you think there will be another solution in the future, then that is something which is a hindrance	It is an enormous challenge to charge 80 trucks with 850 kWh of battery capacity overnight. We are talking about a smaller Swedish town which we will need to build-out a transformer for
Economic	Without financial support, not many are ready to build charging infrastructure today	It is challenging to find a business model that makes owning charging infrastructure profitable	In the end it is about a haulage contractor feeling that this is an economically acceptable investment	Many of the haulage contractors are interested but they need someone to pay for it on the other end	The trucks become more expensive to buy, but cheaper to drive	The customer does not seem to be willing to pay more for sustainable transport
Uncertainty		It is difficult to forecast, how fast will all of this develop?	Second-hand value and technological lifetime of batteries is uncertain currently	Everyone sits around waiting for uncertain political decisions and technological development	The current logistics system is unpredictable, which will be a challenge when charging will be another parameter to consider	We will be burning through a great amount of learning money now and in three to four years look back and say, what the hell were we thinking? Just because the technological development is so enormously fast-moving
Path Dependency		Given time, would there be any electrification which we could not handle? No, there is not. The hindrance is that we are trying to do it so much faster than what the structures we have built until today have been suited for	The permit processes are too slow and the build-out of electricity production and transmission is moving too slow		If the entire Swedish population were allowed to buy a ticket to the cinemas but there were no limitations to when they can use the ticket to watch a movie, meaning that everyone could go at the same time in the worst case, there would be many empty cinemas. That is sort of how the electrical grid is built	When it comes to permits, the bureaucrats who work at the county administrative boards across the country have to roll up their sleeves and put some pressure on. Here we have an automotive industry transitioning, we have an industry transitioning, but the bureaucracy can not keep up, it takes too much time
Resource Supply	It is a challenge to get a hold of all this competence, everyone within power electronics and the electricity business is screaming for people and competence	Large power transformers have two-year production lead times	There is a shortage of truck drivers within the traditional logistics system		A truck that does not charge in the morning is toast, you will have no earnings that day. Which both results in loss of revenue but could also result in penalties if you have promised to transport something and you can not perform your duty. So there is a completely different uptime requirement	The TSO has a shortage of human resources as they can not deal with the large number of permission requests

6.3 Business Model Innovation to Manage Opportunities and Challenges

This section presents the empirical findings relating to the second research question of this thesis, i.e. how the organisations of the interviewees manage the perceived opportunities and challenges through business model innovation, and by doing so play a role in the development of the electric heavy road transport ecosystem. The findings are divided into the three components of business model innovation, i.e. value proposition innovation, value creation innovation and value capture innovation, as well as business model innovation approach.

6.3.1 Value Proposition Innovation

Several of the interviewees discussed how they were working with new customer offerings in order to take advantage of opportunities or to evade challenges related to the electrification of heavy road transport. Some were taking on a supportive role by offering their customers more consulting services (Interviews TM1, TM2, CIC1, CIC2). Representatives of the truck manufacturers expressed that they were moving closer to their customers since the truck's energy supply becomes part of their business, and something that their customers expect them to solve (Interviews TM1, TM2). Figure 11 below illustrates how the truck manufacturers are identified to extend their customer offering to overcome technical, economic and uncertainty challenges as well as to utilise cooperation and economic opportunities, as an example of value proposition innovation.

Figure 11: An illustration of how the truck manufacturers are identified to extend their customer offering to overcome technical, economic and uncertainty challenges as well as to utilise cooperation and economic opportunities, as an example of value proposition innovation.

In accordance with this, one interviewee expressed that holistic understanding and knowledge about the charging part of the business was seen as a competitive advantage:

"Our business to provide and understand the customer's need for how to charge has been quite an USP [unique selling point] that has made them want to do the business with us. The truck has become somewhat subordinate, it could just as easily have been from another brand, but they choose to buy it from us since we have sort of pieced it all together."

- Charging Strategy and Business Development Manager at Truck Manufacturer 1 (TM1)

The representative of Truck Manufacturer 1 also mentioned one example where they supported a haulage contractor with installation of charging stations and integrated those with a solar cell park and energy storage. The haulage contractor later expressed that the electric trucks were the least interesting part of the deal, it was just seen as a tool used within their operations (Interview TM1). This way of expanding the customer offering was found at both the truck manufacturers and the charging infrastructure companies who also focused on helping the customer in order to provide the best solution:

"I think that what we can do is to lower the threshold for knowledge (...) to be able to offer the right type of service with the right type of solution, adapted to the right needs and with the right structure around. I think it can seem difficult and it can seem challenging in different ways."

- Business Manager E-Mobility at Charging Infrastructure Company 1 (CIC1)

"To think smart, we do not just want to sell things just for the sake of selling, we want it to be of some value. It is clear that I make more money selling a 350 kW charger, but if the customer does not need it, it will come back to me sooner or later (...) so we try to be transparent and say, yes but here you absolutely need nothing more than 50 kW."

- CEO at Charging Infrastructure Company 2 (CIC2)

By extending their customer offering to include more exhaustive solutions, they were mitigating some uncertainty challenges and also exploiting opportunities connected to increased cooperation. The economic opportunity that comes with expanding their value proposition were of course also driving these actors to develop their business models in this way. The CEO at Charging Infrastructure Company 2 also highlighted that they were including energy storage solutions as a part of their comprehensive customer offering, which also involved working with the customers' understanding of the potential synergy effects that could increase the overall value for the customer (Interview CIC2).

In order to overcome some of the path dependency and resource supply challenges affecting the electrical grid, one of the interviewees expressed the need to improve the customer interface, which will demand both development of internal resources and an increased digitalisation (Interview EGO3). The customer expects faster price and feasibility estimations (Interviews EGO2, EGO3), thus it would be favourable if they could enter basic data themselves (e.g. a location and a power requirement) and get an automatic response without having to wait for administration and time-consuming investigations (Interview EGO3). On a similar note, the Head of Electrical Grid at Electrical Grid Owner 2 discussed their work of structuring and standardising products in order to decrease lead times and enable both faster and new customer offerings (Interview EGO2).

The interviewees were also expressing how the electrification of heavy road transport was stimulating business model innovation in the form of new customer relations or even completely new customer segments (Interviews CIC1, CIC2, EGO1, EGO2, EGO3, HC1, HC3, TM1, TM2). In order for the actors to take a more holistic approach as presented earlier, it was considered important to forge closer customer relationships and the bond to the customers grew stronger naturally through this process (Interviews TM1, TM2, CIC1, CIC2). Interviews with the charging infrastructure representatives also revealed how the electrification was providing new customers which in turn were affecting their business model:

"And we also see a large number of new types of customers compared to our traditional business. Also there, I think the business model will be affected and we need to be innovative and more fast-paced."

- Business Manager E-Mobility at Charging Infrastructure Company 1 (CIC1)

Moreover, the representative of Truck Manufacturer 1 was discussing how their customer segments had started to shift due to the electrification of the transport sector:

"Of course we have been delivering trucks for garbage disposal before, but now when it comes to electrification, it will probably quickly start to become much more vehicles in the segment that we have traditionally not been so big in, the one that has to do with local or regional transport or solutions."

- Charging Strategy and Business Development Manager at Truck Manufacturer 1 (TM1)

Many interviewees underscored that their customer relationships will be strengthened and tightened due to the electrification of heavy road transport (Interviews PA, CIC1, CIC2, TM1, TM2, EGO1, EGO3, HC1, HC2, HC3). The economic challenge of larger investment costs will have to bring customers closer through longer agreements (Interview HC3). Increased transparency will also be needed in order to decrease the risk attributed to volatile fuel prices and when entering a collaboration relating to large investments:

"With such large investments that we are going to enter into, there must be longer contract periods for example, and there must be transparent agreements where you have transparency and can see these price variations. (...) you have to be very open and I think the relationships will be very long lasting (...) if a customer builds charging infrastructure and we buy electric trucks, we are together making a very large investment to run this assignment and then we are probably talking about a six, eight-year agreement, instead of three as it is today."

- Project Leader (Former CEO) at Haulage Contractor 3 (HC3)

Interviews with the electrical grid owner representatives showed that they all were experiencing and working with new customer relationships as well (Interviews EGO1, EGO2, EGO3). The Head of Innovation at Electrical Grid Owner 1 was experiencing a shift in their customer dialogues in order to gain a deeper understanding of how the requested power connections were to be used. This provided a way of avoiding some of the electrical grid challenges by working with conditional connections for certain customers (Interview EGO1). Increased customer interaction was also discussed during the interviews with the representatives of the other two electrical grid owners, who said that they were working to increase the knowledge in both directions (Interviews EGO2, EGO3). It was considered important to enhance the understanding of the electrical grid owner's business in order to create customer value (Interview EGO2). But it was also important to understand the new customer's needs in order to price correctly and maintain fairness:

"We have to review our tariffs, we get a new type of customer into our network that we have to price correctly. The Electricity Act certainly has a fairly comprehensive description about the requirement for the tariffs, they must be cost-effective and non-discriminatory, so it is important that we include this new customer type in a correct way."

- Head of Electrical Grid at Electrical Grid Owner 3 (EGO3)

6.3.2 Value Creation Innovation

The value creation activities identified through the interviews related to new capabilities, new partnerships, new technologies and new internal processes. Many interviewees emphasised the need for new competence in order to handle many of the challenges they experienced when shifting to electric heavy road transport (Interviews TM1, TM2, PA, GO1, HC1, HC2, HC3, CIC1, CIC2). Internal training and recruitment were considered necessary to increase the competence relating to electric vehicles. For some it was important to have proficient technicians in order to keep a high availability of equipment, both electric heavy trucks and charging infrastructure (Interviews GO1, TM1, TM2, CIC2). Others highlighted the need for increased internal competence in order to demonstrate expertise through customer touchpoints (CIC1, CIC2, HC1, TM1, TM2).

One prominent challenge experienced by many of the participants related to passivity and lock-in effects causing slow ability to change. This was addressed by creating new departments focusing more closely on the sustainability transition or even directly on the electrification of the transport sector (Interviews PA, TM1, TM2, HC3, CIC1). One interviewee described the new department and its focus area:

"It is a central function whose task is to investigate how the charging will develop. It is a central part of our offer to the customers, for customers who buy electrically powered vehicles in the form of trucks or buses, they expect that we as a supplier of these vehicles also are able to give them advice on how to solve the fuel supply, with electricity in this case. So it is like the main task of our department."

- Charging Strategy and Business Development Manager at Truck Manufacturer 1 (TM1)

Some actors were changing their value creation by forging new working processes. The Head of Operations at Haulage Contractor 2 explained how they were expecting to re-work their driver shifts by changing from two shifts to one shift, in order to create a better fit for the new charging patterns needed in order to evade the challenge connected to having to stop and charge the truck (Interview HC2).

Regarding new processes, the representative of Truck Manufacturer 2 highlighted how the electrification of heavy road transport was affecting the whole company:

"Every part of our company is affected, it's everything from sales competence to networks around our partners, to production, to product development, to aftermarket, dealer networks, service stations, everyone is affected in one way or another."

- Director Electromobility Business Development at Truck Manufacturer 2 (TM2)

The interviewee also shed light on their effort to create new processes in order to capture the opportunities and evade the challenges connected to the sales of battery electric trucks:

"We are looking into a couple of different areas, that's probably why it's called business development. So we will see where it lands in all the other issues that come with electromobility then, how to handle batteries, how to handle charging, how to attack the adjustment that will happen in the traditional approach with the supplier, final assembly and sales to customers eventually."

- Director Electromobility Business Development at Truck Manufacturer 2 (TM2)

The Head of Electrical Grid at Electrical Grid Owner 3 explained how they had gained experience of how to create new processes with an increased number of requests for the connection of solar panels. Everything was new in the beginning, involved actors were uncertain of the working process and the electrical installers were inexperienced, which came with a lot of technical and administrative issues. But now, after adapting their internal processes, such installations were performed quickly and smoothly. The same will probably be the case when connecting charging infrastructure and accordingly, new processes will be developed that will eliminate some of these challenges and provide faster routines and better solutions to the user interfaces (Interview EGO3). Figure 12 below illustrates how the electrical grid owners are identified to create new processes to overcome technical and resource supply challenges as well as to exploit utilisation opportunities, as an example of value creation innovation.

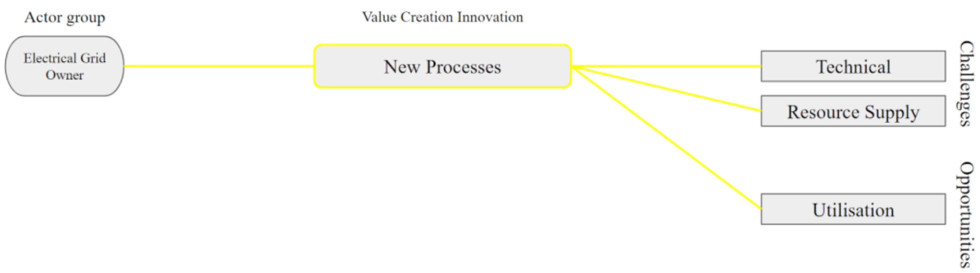


Figure 12: An illustration of how the electrical grid owners are identified to create new processes to overcome technical and resource supply challenges as well as to exploit utilisation opportunities, as an example of value creation innovation.

The Head of Global Logistics at Goods Owner 4 also mentioned how they were working with new processes related to the transport of their goods by differentiating their need for specific transport flows.

Instead of putting strict demands on their haulage contractors considering all flows, they tried to exert flexibility with regards to transit time, for example:

"We are also trying to differentiate our needs, i.e. instead of saying that there should be a certain transit time and a certain CO_2 emission, we say that between A and B there can be different transport products. Much like when you go online and buy something, you can get several different shipping options. Something like that is how we have thought about addressing this problem and in that way also maybe the willingness to pay, or it is usually a trade-off in some way, usually in money or in transit time, and thus be able to find the ways forward. We believe this is more dynamic or more efficient than trying to increase these requirements every other year in a procurement."

- Head of Global Logistics at Goods Owner 4 (GO4)

Many of the interviewees expressed how they were working with new partnerships, thus taking advantage of the cooperation opportunities while simultaneously managing some of the coordination and uncertainty challenges (Interviews HC1, HC2, CIC1, CIC2, TM1, TM2, GO4, GO5, EGO3, PA). The C-Level Executive at Port Authority saw the potential to initiate new partnerships with actors that were transporting goods to and from the port (Interview PA). This could work similarly to how the port was investing in electrical connection for berthing ships at their site, where the shipping company was making a corresponding investment to their ships to enable such a connection. On land it would be charging infrastructure at the port and at the site of the goods owner or haulage contractor (Ibid.). Representatives of the haulage contractors and the truck manufacturers reported that they were initiating new partnerships in order to secure energy supply of vehicles. Both charging infrastructure and hydrogen production was mentioned:

"We will surely be dependent on working with new partners (...) working with collaboration to actually secure the [charging] infrastructure together. We can see that this is a work that is already going on right now, where we work with new partners."

- Head of Operations at Haulage Contractor 2 (HC2)

"There will be some new ones [partnerships]. We have not cared very much about who builds the pumps for diesel, for example before, it has been a completely separate business."

- Director Electromobility Business Development at Truck Manufacturer 2 (TM2)

New partnerships were being created between haulage contractors and truck manufacturers but also electrical grid owners and charging infrastructure companies. The Head of Electrical Grid at Electrical Grid Owner 3 mentioned two new partnerships, one together with a haulage contractor where they were keeping a close dialogue in order to enable installation of both charging infrastructure and hydrogen production at their site. The other one was in cooperation with a charging infrastructure company that provided data on charging and behavioural patterns. This was later utilised in order for the electrical grid owner to make simulations to build preparedness considering investments and get an idea of how they could enable customer management through the initiation of new tariffs (Interview EGO3). Some of the representatives of the goods owners also mentioned how new partnerships could be initiated in order to eliminate some of the investment uncertainties (Interviews GO4, GO5). They saw the opportunity to ensure transport volumes by composing stricter requirements on their suppliers and entering into longer agreements, which was considered a new type of partnership (Ibid.).

As regards new technologies and equipment, several interviewees expressed how the electrification of heavy road transport were making them incorporate new technologies relating to battery production as well as charging and energy storage solutions (Interviews TM1, TM2, GO1, EGO1, EGO2, EGO3, HC3). The representatives of the truck manufacturers both mentioned how they were working with new technologies in order to provide charging equipment to their customers, thus taking advantage of technical opportunities (Interviews TM1, TM2). One of them also mentioned how they were building a new facility for their own battery production (Interview TM1). The Project Leader (Former CEO) at Haulage Contractor 3 gave one example of a new technical project where they were testing a trailer covered in thin-film solar cells that enabled charging while driving and that could provide electricity to the electrical grid when idle (Interview HC3). On the same note, two representatives of the electrical grid owners reported how new power control technologies were required to receive more decentralised electricity to their grid, which could come from the batteries of electric trucks for instance (Interviews EGO1, EGO3). Similar technologies would also be required to enable more flexible consumption of electricity to take advantage of utilisation opportunities (Interviews EGO1, EGO2, EGO3).

6.3.3 Value Capture Innovation

Out of the three components of business model innovation, value capture innovation was the least mentioned component. As regards new revenue models, the representatives of the charging infrastructure companies reported a customer preference change towards leasing and other financial alternatives, to manage the high investment costs of both electric heavy trucks and the associated charging infrastructure (Interviews CIC1, CIC2). One of the charging infrastructure company representatives described that they were looking into flexible financial models (Interview CIC2), whereas the other charging infrastructure company representative stated that they already provided such models through monthly payments or extended payment terms, including the cost for the charging infrastructure and service (Interview CIC1). Through such revenue models, the financial threshold for the customer could be lowered and a stable foundation of recurring revenue streams could be built (Ibid.). Figure 13 below illustrates how the charging infrastructure companies are identified to create new revenue models to overcome economic and uncertainty challenges as well as to utilise economic opportunities, as an example of value capture innovation. In addition, the representatives of the truck manufacturers expressed that they would be providing financial solutions for both the electric trucks as well as the associated charging infrastructure, for similar reasons (Interviews TM1, TM2).

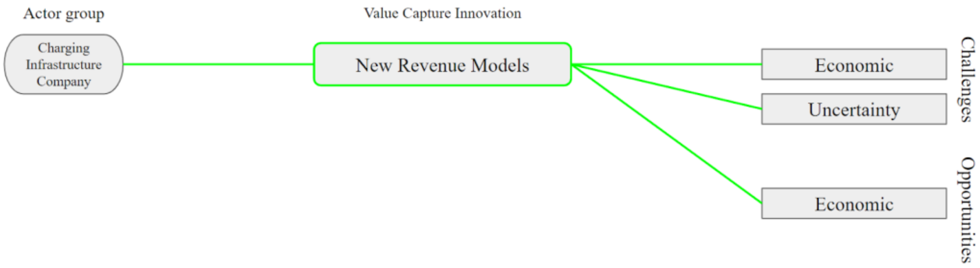


Figure 13: An illustration of how the charging infrastructure companies are identified to create new revenue models to overcome economic and uncertainty challenges as well as to utilise economic opportunities, as an example of value capture innovation.

As regards new cost structures, the Project Leader (Former CEO) at Haulage Contractor 3 reported that their cost structure will differ depending on the transport service provided (Interview HC3). On the one hand, long haul transport might require high power public charging which is more expensive than depot or semi-public charging. On the other hand, regional transport might only require low power overnight charging and charging during loading and unloading, which comes with a lower cost. Moreover, the interviewee mentioned the possibility to purchase a truck without a battery and employ battery swapping instead of charging, and the possibility to sell transport services excluding the energy cost. The battery could be swapped or charging could be provided by the transport buyer, implying that the haulage contractor could lower its costs and sell its service at a lower price without lowering its margin (Ibid.).

6.3.4 Business Model Innovation Approach

Three different approaches to business model innovation were demonstrated during the interviews, namely a proactive approach, a reactive approach and an inactive approach. First, a proactive approach to business model innovation was implemented at Charging Infrastructure Company 1 according to the company representative (Interview CIC1). The company was trying to find solutions together with truck manufacturers suited to the electric heavy road transport market five to ten years from now, by challenging each other and the way they do business. According to the interviewee, this possibility to innovate with the risk of failure within the market for electric heavy road transport was made possible through a belief that this market will become profitable in the future and through revenue streams from other currently profitable markets. Additionally, the firm of one interviewee exhibited a proactive approach by trying to be far-sighted and avoid becoming a system bottleneck in the future by planning ahead and closely following current developments (Interview EGO3). Another interviewee described how its organisation was trying to become better at challenging the status quo of business models by expressing how they believed things should be done, and “not sit around and wait for others to serve them a solution” (Interview GO4). Yet another interviewee spoke of how its organisation was adopting a flexible mindset to stay open to change, in order to facilitate development:

“We will develop the infrastructure based on future demands. (...) We are trying to be open to thinking differently and also be open to enacting new roles which we have traditionally not enacted, and one such role could for example be to invest in and maybe even own and operate charging infrastructure. (...) We could consider that to make something happen.”

- C-Level Executive at Port Authority (PA)

Second, a reactive approach to business model innovation was exhibited by Charging Infrastructure Company 1 in addition to its previously described proactive approach, as the interviewee depicted how its organisation adjusted its business model based on market demand and that a drastic change in the future would be dealt with as it appears (Interview CIC1). Two other interviewees expressed that their organisations were trying to be adaptable to changes in customer preferences by making incremental and continuous upgrades to their business models (Interviews GO2, GO3). Another interviewee highlighted the issue of passiveness due to an immature market:

“When a market is not fully mature and when you have business models which are not fully viable, then there is a great risk everyone waits and then nothing happens.”

- Head of Electrical Grid at Electrical Grid Owner 3 (EGO3)

Third, an inactive approach to business model innovation was exhibited by interviewees who expressed that the transition to electric heavy road transport did not affect their business models and who did not see a need for change (Interviews EGO2, GO4). The roles required to enable the transition already exist and there is essentially no change required even though the power need of the electric trucks is much greater as compared to passenger EVs, according to one interviewee (Interview TM2). Another interviewee underlined the risk of companies accusing other companies of being the ones having to change:

“It is like the typical discussion, ‘everyone else can change but we already have a good model’.”

- Business Manager E-Mobility at Charging Infrastructure Company 1 (CIC1)

6.3.5 Summary

The above findings exhibit a great number of business model innovation activities within the emerging electric heavy road transport ecosystem. One of the most prominent activities relates to different types of collaboration or cooperation activities expressed as new customer relations, new customer segments and new partnerships. The interviewees who discussed new customer offerings also indicated how these new offerings often included increased dialogue and understanding of the customer needs in order to provide the best possible offering to the customer. Consequently, the need for more interaction between the ecosystem actors was expressed by many participants and in various ways. However, there were also interviewees who expressed challenges with increased collaborative elements since these could hinder competition and create dependencies unfavourable for some, indicating that these types of business model innovation sub-components need to be designed to benefit more actors than the initiator.

All sub-components of business model innovation as presented in the conceptual framework in Figure 1 were identified, except for new channels. As shown in Figure 14 below, some of the sub-components were found to be innovated within multiple actor groups as well as to handle several different challenges and opportunities. The least identified sub-components were within value capture innovation, while new partnerships were identified among all actor groups.

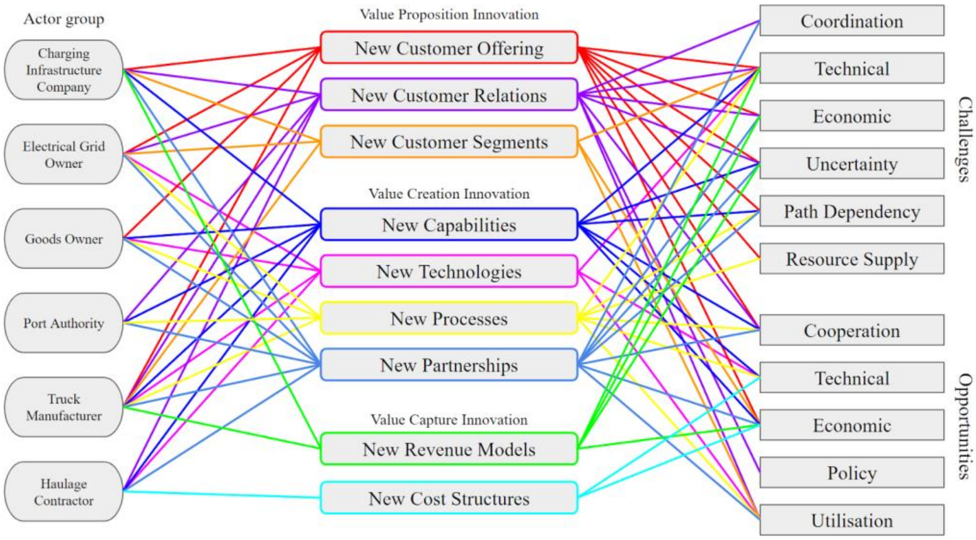


Figure 14: Illustrates all identified connections between actor groups and sub-component of business model innovation (left-hand side). The figure also illustrates which challenge or opportunity that was identified to be managed through which business model innovation sub-component (right-hand side).

Beyond business innovation components and sub-components, the innovation approach was also identified and discussed based on the interview responses. The six different actor groups were deemed to cover the entire spectrum, from an inactive to a proactive innovation approach, as illustrated in Figure 15 below. Some interviewees within the same actor group expressed different approaches to business model innovation. The results should however be analysed with the number of representatives per actor group in mind, as a greater number of representatives would imply a greater distribution of answers.

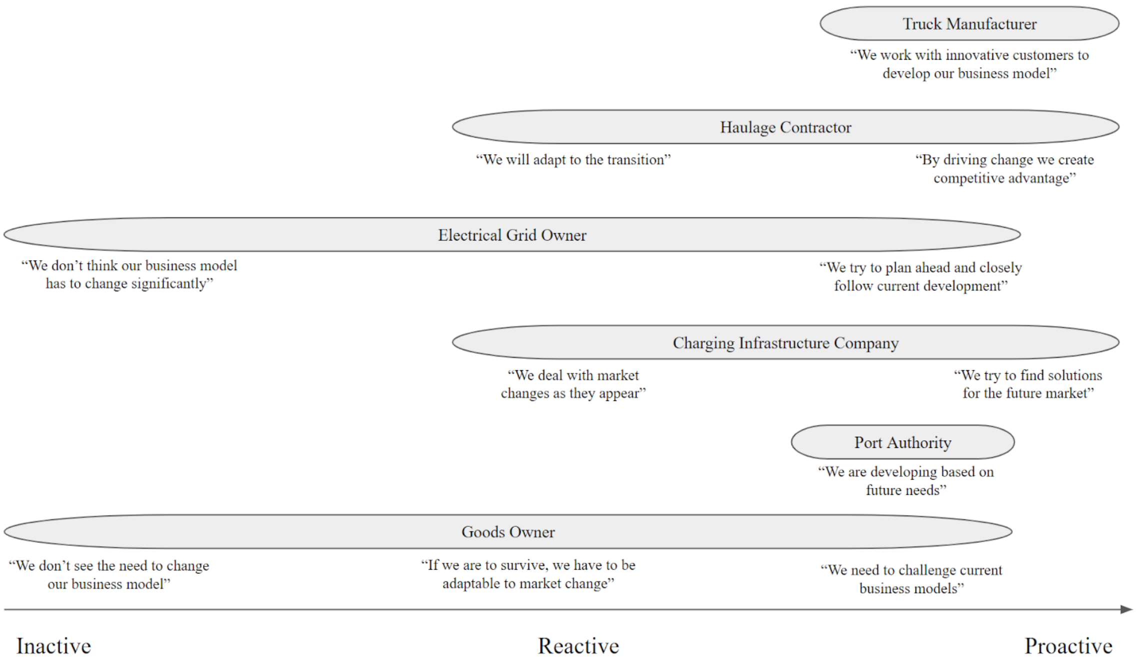


Figure 15: Illustrates how the actor groups are identified to take various approaches to business model innovation. Some actor groups exhibit a greater distribution due to lack of consensus among the interviewees within the same group.

7. Discussion

This chapter discusses the empirical findings of this thesis in relation to previous literature. The varying perceptions of business model opportunities and challenges within the ecosystem are discussed, as well as how the ecosystem actors innovate their business models in terms of what sub-components are changed and through which innovation approach. Followingly, managerial and theoretical implications are considered as well as limitations and future research.

7.1 RQ1: Perceptions of Business Model Opportunities and Challenges

This section discusses the empirical findings relating to the first research question of this thesis, i.e. how the ecosystem actors perceive the transition to electric heavy road transport in terms of business model opportunities and challenges, and what the implications are for the complexity and the development of the ecosystem. As indicated, the interviewees representing actors of the studied ecosystem perceived a multitude of business model opportunities and challenges with the transition. On the one hand, the interviewees agreed on several opportunities (e.g. increased cooperation and competitive advantage) and several challenges (e.g. economic feasibility and uncertainty). On the other hand, the interviewees for instance disagreed on whether current technological development was considered a challenge or an opportunity, and whether the growing ecosystem with traditional transport ecosystem actors and traditional electricity ecosystem actors coming together would bring about cooperation opportunities or coordination challenges. Moreover, the interviewees expressed that their organisations could consider enacting a wide range of potential roles in the transition to electric heavy road transport. By contrast, there was a fairly high level of agreement with regards to critical roles, which were considered being the financing and building of the different technical components.

Based on the above, the studied ecosystem exhibited a varying level of what Adner would label alignment (Adner, 2017). Alignment concerns the level of agreement regarding ecosystem positions and activity flows. According to Adner (Ibid.), all actors are satisfied with their positions in a successful ecosystem. Both the traditional heavy road transport ecosystem and the traditional electricity ecosystem most likely exhibit a high level of alignment, where actors are satisfied with their positions. By contrast, with the emergence of an electric heavy road transport ecosystem, these two traditional ecosystems begin to merge, implying that actors who have previously not interacted must now align on the positions and activity flows of the emerging ecosystem. As shown by the empirical findings of this thesis, the studied ecosystem does not seem to have reached an aligned state as there are different perceptions of business model opportunities and challenges, as well as opinions on potential and critical roles in the ecosystem. Adner (Ibid.) does however argue that alignment requires compatible and not common incentives, motives and end goals, implying that the ecosystem can sustain some level of divergence between actors. As such, the success of the electric heavy road transport ecosystem does not hinge on the agreement of opportunities and challenges. Instead, the perceptions of the different actors must be compatible and actors must not counteract each other if the ecosystem is to develop successfully.

In addition to alignment, the multilaterality of relationships within the studied ecosystem implies highly interdependent actors (Adner, 2017), and the perception of each ecosystem actor may thus have implications for multiple other ecosystem actors. Hence, how one ecosystem actor perceives opportunities and challenges and how this perception is subsequently communicated to the other ecosystem actors, will affect the development of the ecosystem. In addition to relationships being multilateral, the ecosystem actors exhibit complementary relationships in accordance with Jacobides (2018), implying that activities carried out by one actor are dependent on activities carried out by another actor. For example, the building of charging infrastructure is dependent on the financing of charging infrastructure. The same applies for the technical components deemed critical to the ecosystem. The electric heavy trucks do not function without charging infrastructure and electrical grid infrastructure, and could greatly benefit from local electricity production and/or storage. Simultaneously, the value of the electric heavy trucks increases as the availability of charging infrastructure increases, and the value of the charging infrastructure increases as the number of electric heavy trucks increases, also known as network effects (Ibid.). In addition, the different electrification technologies are complementary in nature, as one technology may be better suited for a certain application as compared to another technology. Thus, there are complex relationships between actors, activities, technical components and electrification technologies, where the development of one actor, activity, technical component or electrification technology will impact the development of other actors, activities, technical components and electrification technologies. As argued by Adner & Kapoor (2010), "the success of an innovating firm often depends on the efforts of other innovators in its environment". As such, the development of the ecosystem in its entirety is complex.

With this complexity in mind, it may be difficult to avoid a future trajectory which is suboptimal at an ecosystem level without some level of hierarchical governance. The ecosystem actors are not fully aligned and their relationships are both multilateral and complementary, implying that coordination is difficult when decision-making is distributed among ecosystem actors. In contrast to Jacobides (2018) who argued that ecosystems by definition are not "fully hierarchically controlled", the ecosystem could possibly benefit from one or several actors enacting a leadership role to guide ecosystem development at an early stage, and make initial investments which can catalyse the network effects of the electric heavy trucks and charging infrastructure. This is in accordance with Dedehayir et al. (2018), who studied role enactment during innovation ecosystem birth and highlighted the importance of the leadership role when ecosystem actors begin to interact and it does not exist a structure for their interconnection.

7.2 RQ2: Business Model Innovation to Manage Opportunities and Challenges

This section discusses the empirical findings relating to the second research question of this thesis, i.e. how the ecosystem actors innovate their business models to manage perceived business model opportunities and challenges, in order to play a role in the development of the electric heavy road transport ecosystem. The empirical findings from the conducted interviews demonstrate that actors within the emerging ecosystem are developing their business models in various ways, based on their perceptions of opportunities and challenges that the emerging ecosystem entails. All sub-components of business model innovation adopted from Clauss (2017), except new channels, were identified within the ecosystem. Interestingly, new channels was the least occurring business model innovation sub-component in literature reviewed by Clauss (2017), which implies that it may be the least innovated sub-component of the business model in general. Moreover, the distinction between identified business model innovation approaches as shown in Figure 15, demonstrates how certain ecosystem actor representatives expressed the willingness to innovate their business models in order to stay ahead of predicted ecosystem developments or to drive ecosystem change. While some ecosystem actor representatives demonstrated a higher degree of consensus regarding the innovation approach, other ecosystem actor representatives expressed contradictory attitudes to how their business model would or should be developed within the emerging ecosystem. The goods owner representatives are one example of where this attitude differed markedly, which implies that some were willing to actively change current ways of working in order to participate in the ecosystem development, while others assumed that their current processes would fit within the future ecosystem and that change internal to the ecosystem will have to be dealt with by others.

By identifying the drivers to business model innovation and in turn which components of the business model that are innovated, the question of how firms adapt their business models to an evolving ecosystem as proposed by Zott & Amit (2013) is addressed. In addition, Rong et al. (2018) suggested that change at an ecosystem level shapes the development of the business models of firms within said ecosystem. However, as this thesis also analysed which approach to business model innovation firms employed (i.e. reactive or proactive), conclusions could be drawn of which firms act to shape the development of the emerging ecosystem. This would imply that proactive business model innovation can evoke ecosystem development in contrast to Zott & Amit (2013) and Rong et al. (2018), who argued that it is change at an ecosystem level which induces business model innovation and not the other way around. Moreover, to further expand the study by Saebi et al. (2017), where business model development was differentiated between business model adaptation (reactive) and business model innovation (proactive), the empirical findings of this thesis can be used to further analyse this distinction and address the question of how opportunities and challenges are managed through business model innovation, and through which innovation approach.

Multiple ecosystem actor representatives expressed the need for firms with higher profit margins or with revenue streams from other currently profitable markets to lead the way and take the risk arising from an uncertain future, thus enacting a leadership role within the ecosystem. The findings are also indicating that multifaceted actors (i.e. charging infrastructure companies) and firms with strong capital flows (i.e. truck manufacturers) are taking a more proactive approach to business model innovation. As regards sub-components of business model innovation, it is also these ecosystem actors that were identified to develop most of the different components, as shown in Figure 14. As Adner (2017) discusses, the leader shapes the ecosystem while other actors accept the follower role, thus acting in accordance with the plan of the leader. This would imply that both the charging infrastructure companies and truck manufacturers are enacting a leadership role. Consistent to Adner (Ibid.), it is not unusual for more than one firm to enact a leadership role within the same ecosystem through shared or collaborative models. As previously proposed, hierarchical governance could benefit the emerging ecosystem at this early stage of development. Hence, there should not be much resistance from the other ecosystem actors against the leadership role enactment of the charging infrastructure companies and truck manufacturers, and the two actors will potentially have a great influence over shaping the development of the ecosystem. As such, the charging infrastructure company-truck manufacturer relationship will be imperative to the overall success of the ecosystem.

7.3 Managerial Implications

The empirical findings of this thesis have managerial implications for practitioners within the studied ecosystem, for practitioners within other ecosystems transitioning to electric heavy road transport and for practitioners within developing ecosystems in general. By exploring how the transition to electric heavy road transport is perceived by representatives of the actors within the studied ecosystem, key opportunities and challenges are highlighted which need to be managed individually or collaboratively by the ecosystem practitioners. By making opportunities and challenges explicit, cooperation and coordination within the ecosystem can be more easily facilitated. Potential gaps in role enactment have in addition been illustrated by investigating potential and critical roles in the transition to electric heavy road transport. The ecosystem practitioners can also gain an understanding of how they affect each other by highlighting the complex interdependence between ecosystem actors. Practitioners of other ecosystems facing a transition to electric heavy road transport could in turn benefit from understanding what the business model opportunities and challenges are with this transition as perceived by the representatives of the actors within the studied ecosystem. In addition, they could understand what other ecosystem actor representatives could consider as critical roles and what roles they could consider enacting. This is knowledge which the practitioners can make use of in their own transition. Moreover, practitioners within developing ecosystems in general could benefit from understanding that ecosystem actors perceive opportunities and challenges differently, and that it is essential to understand that these differing perceptions adds to the complexity of ecosystems. This especially holds true when ecosystem development is at an early stage and when the actors are not fully aligned on ecosystem positions and activity flows. As a consequence, it is important for practitioners of developing ecosystems in general to understand that an ecosystem leader who can guide the ecosystem development at this early stage could prove beneficial.

With regards to business model innovation, the empirical findings of this thesis could aid practitioners within the studied ecosystem in understanding how other ecosystem actors are innovating their business models to participate in ecosystem development, which in turn can increase the understanding for if there is a gap in role enactment required to enable the transition to electric heavy road transport. Ecosystem practitioners could also learn from the other practitioners in how they manage opportunities and challenges through business model innovation. Practitioners in other ecosystems facing this transition could in turn observe how the transition unfolds as a consequence of business model innovation within the studied ecosystem, to learn from success stories and to avoid pitfalls. Finally, practitioners within developing ecosystems in general could learn from the empirical findings of this thesis that it is possible to steer the ecosystem development through a proactive business model innovation approach, and that such an approach could benefit the ecosystem development in its entirety during its early stages.

To conclude the managerial implications, below follows a list of key takeaways for practitioners affected by the electrification of heavy road transport and for practitioners within developing ecosystems in general. The key takeaways are based on the empirical findings of this thesis regarding perceived business model opportunities and challenges and how these are managed through business model innovation:

- There is a need for pilot projects to get valuable early-phase experience and a need for transparent dialogue to improve coordination.
- By improving the understanding of the customers' needs, the best technical solution can be supplied and maximum value can be achieved.
- There is a growing demand for sustainable transport but achieving economic feasibility is critical to the transition.
- Flexibility and foresight are important to stay ahead of demand and to avoid potential bottlenecks with regards to financing, building and operating the technical components.
- The charging infrastructure is considered essential in the transition and many of the interviewees could consider carrying out activities relating to it. This could imply coordination difficulties if not handled appropriately.
- Close customer interaction and providing holistic solutions proactively creates a competitive advantage and the possibility to steer the development of the ecosystem.

7.4 Theoretical Implications

The findings of this thesis provide new empirical material enriching the existing business model innovation and ecosystem theory. The results further exhibit that the mechanisms presented in previous literature are applicable to the context studied within this thesis. Followingly, it is also argued that these theoretical findings would be applicable within other contexts relating to both emerging ecosystems and business model innovation separately, and particularly when combining the two concepts. By linking ecosystems and business model innovation, this thesis has contributed to the scarce but interesting research area found at the intersection of these two concepts. It is demonstrated how ecosystem actors perceive opportunities and challenges which in turn affects their efforts to innovate their business model.

By applying ecosystem theory, conclusions are also drawn considering ecosystem development and its interdependence with business model innovation. The findings strengthen the literature claiming how ecosystem changes induce business model innovation, but that it depends on if the said actor has employed a reactive innovation approach. In contrast to existing literature, it seems that proactive business model innovation could shape the development of the ecosystem and that such an approach results in the emergence of an ecosystem leader. Due to this, it is not only interesting to study how, in terms of which components or sub-components of one's business model which are innovated, but also which approach to business model innovation is employed. As the literature claims, the leader shapes the ecosystem while others accept to follow. The empirical findings of this thesis argue for the need of an ecosystem leader within emergent ecosystems in accordance with previous literature. Adding to this, by combining ecosystem and business model innovation theory, it was demonstrated how a proactive business model innovation approach brings forth an ecosystem leader and that followers employ a reactive business model innovation approach.

7.5 Limitations and Future Research

The method of this thesis was applied based on the exploratory approach employed by the researchers, which was deemed appropriate since the research at the intersection of business model innovation and ecosystems is scarce. However, qualitative interview studies have some natural limitations arising from e.g. faulty interpretations made by the interviewees or interviewers. The use of semi-structured interviews suits exploratory studies but implies a decreased possibility to compare the interviewees' answers, since the probing questions varied to some degree, depending on what was found interesting during the different interviews. Another circumstance that decreases the comparability is that the interviewees held different positions at their respective companies and actors within the same actor group operated within a mix of industries, which in turn should have affected their perceptions. Despite these limitations, general conclusions have been drawn from this cross-sectional study. Deeper understanding of the findings presented in this thesis could be reached by focusing on one specific actor group and performing multiple interviews within this group, in order to verify or nuance the findings argued for in this thesis. Another approach would be to apply a multiple case study in order to draw more evident conclusions on the transferability between the ecosystem examined in this thesis and other ecosystems. A longitudinal study that closely monitors ecosystem development over time to draw further conclusions of the affecting factors could also enrich the findings presented here.

The findings within this thesis provides many interesting areas for future research. The results have for instance shown which technical component is perceived as the most prominent challenge on an ecosystem level, namely the development of the electrical grid. Thus, a deeper analysis of how to overcome this challenge would certainly contribute to the development of electric heavy road transport. Moreover, a study focusing specifically on the mechanisms affecting ecosystem development could bring further conclusions on the interdependence between business model innovation and ecosystem development by also taking external factors into account, such as economic or environmental policy measures. Lastly, the result of this study highlights the demand for increased collaborative elements within the studied ecosystem. A deeper analysis of alternative collaboration models by highlighting more specific opportunities and challenges could thus provide many interesting findings and progress the alignment of the ecosystem, and in its extension support the transition to large-scale electric heavy road transport.

8. Conclusion

This chapter summarises and concludes the thesis with regards to how the actors of the studied ecosystem perceive the transition to electric heavy road transport in terms of business model opportunities and challenges, and in turn how the ecosystem actors manage the perceived opportunities and challenges through business model innovation, in effect participating in ecosystem development.

This thesis addresses how actors of the emerging electric heavy road transport ecosystem perceive business model opportunities and challenges with the transition to electric heavy road transport, what roles these actors could potentially consider enacting in the transition and what roles are considered critical. From interviews with representatives of the ecosystem actors, a wide range of opportunities and challenges are identified, as well as differing perceptions of specific opportunities, challenges and roles. It is argued that these differing perceptions add to the complexity of the emerging ecosystem, in addition to the multilateral and complementary relationships between actors. Such complexity could be managed by one or several ecosystem actors enacting a leadership role to guide ecosystem development at its early stages.

Moreover, how the ecosystem actors manage the perceived opportunities and challenges through business model innovation and thus participate in the development of the ecosystem is addressed. From interviews with representatives of the ecosystem actors, the ecosystem actors are demonstrated to innovate all but one sub-component of the business model to manage these opportunities and challenges, where some actors are innovating to a greater extent than others and in turn managing a greater number of opportunities and challenges. In addition, some ecosystem actors are demonstrated to proactively innovate their business model to drive ecosystem change, as compared to the ecosystem actors who reactively innovate their business model to adapt to change. It is argued that it is the ecosystem actors who proactively innovate a great number of sub-components of the business model who will enact a leadership role and steer the development of the ecosystem, whereas the other actors follow and will have to adapt to the ecosystem leaders. Thus, by combining ecosystem and business model innovation theory, it is demonstrated that in addition to that development at an ecosystem level induces business model innovation, business model innovation inversely induces ecosystem level development. In addition to these theoretical implications, the thesis entails managerial implications, such that it is essential for practitioners to make opportunities and challenges explicit to facilitate cooperation, and coordinate how opportunities and challenges should be managed within the ecosystem.

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Appendix

A. Interview Questionnaire (Translated from Swedish)

Part 1: Introduction and the current business model

- 1.1 What is your current role at company X and in what way are you familiar with the business model of the company?
- 1.2 How would you briefly describe the business model of company X?
  - 1.2.1 What is the value proposition of company X, i.e. what do you offer your customers?
  - 1.2.2 How does company X create this value, i.e. how is this value realised?
  - 1.2.3 How does company X capture this value, i.e. how do you charge your customers and generate revenue?

Part 2: Business model opportunities and challenges with the electrification of heavy road transport

- 2.1 How is your business model affected today by the electrification of heavy road transport and how do you think it might be affected in the future?
- 2.2 What business model opportunities do you see with the electrification of heavy road transport along E16 Borlänge - Gävle hamn and in general?
- 2.3 What business model challenges do you see with the electrification of heavy road transport along E16 Borlänge - Gävle hamn and in general?
- 2.4 How do you develop your business model to exploit these opportunities or deal with these challenges?
  - 2.4.1 How do you develop your value proposition?
  - 2.4.2 How do you develop your value creating processes?
  - 2.4.3 How do you develop your value capture mechanism?
- 2.5 How might the development or lack of development of your business model affect other ecosystem actors?
- 2.6 How might other ecosystem actors affect the development of your business model?

Part 3: The ecosystem and roles

- 3.1 Any clarifying questions related to the questionnaire response of the interviewee
- 3.2 Which of the 20 roles in the matrix do you consider being a bottleneck in the ecosystem or of greater importance and why?
- 3.3 Which ecosystem actors do you interact with today and how?
  - 3.3.1 Has there been recent changes?
- 3.4 How do you think this interaction might change in the future following the electrification of heavy road transport?

- 3.5 How can you affect other ecosystem actors to enable the electrification of heavy road transport along E16 Borlänge - Gävle hamn?
    - 3.5.1 Do you want to affect them in a certain direction?
    - 3.5.2 Do you have your own vision of how the electrification of heavy road transport will unfold and your own target of its result?
- 3.6 How can other ecosystem actors affect you to enable the electrification of heavy road transport along E16 Borlänge - Gävle hamn?
- 3.7 How can you together enable the electrification of heavy road transport along E16 Borlänge - Gävle hamn?
    - 3.7.1 What is your opinion on shared ownership or to partly finance a technical component, i.e. to share a role with another ecosystem actor, and do you see any specific opportunities and challenges with such arrangement?
    - 3.7.2 Is there a certain actor you could share a role with?
- 3.8 Are you of the opinion that a leader or coordinator within the ecosystem is required to enable the electrification of heavy road transport along E16 Borlänge - Gävle hamn? Why/why not? Which actor would that be?

B. Definition of Activities and Technical Components (Translated from Swedish)

Activities:

- **Finance:** Contribute with financial means to enable construction
- **Build:** Responsible for project development, construction and/or installation
- **Own:** Buy/take over ownership when construction is finalised (if a component has not been financed with the purpose to maintain ownership)
- **Operate:** Responsible for service, software, control, payment systems, planning
- **Use:** (Customer) Direct usage. Use and pay for the usage of a component

Technical Components:

- **Electric heavy trucks:** Including battery and components enabling stationary/dynamic charging
- **Charging infrastructure:** Stationary (charging station) and dynamic (overhead line/rail in road/wireless) charging
- **Electrical grid infrastructure:** Local connection with the purpose of enabling charging of electric heavy trucks. Via property or directly to the local electrical grid
- **Electricity production/storage:** Electricity production and potentially storage to relieve the electrical grid and decrease the purchasing of electricity, with the purpose of enabling charging of electric heavy trucks

C. List of Business and Management Journals

Table C: List of business and management journals used as search criteria during literature search and review.

Journals	
Technovation	Journal of Management
Technological Forecasting and Social Change	Journal of Management Studies
Strategic Management Journal	Harvard Business Review
Research Policy	Global Strategy Journal
R&D Management	California Management Review
Organisation Studies	Administrative Sciences Quarterly
Organisation Science	Academy of Management Review
MIT Sloan Management Review	Academy of Management Journal
Management Science	Academy of Management Annals
Long Range Planning	Academy of Management Perspectives
Journal of Product Innovation Management	Academy of Management Discoveries

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