CHALMERS
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Insights Into Emobility

How Introduction of Electric Trucks May Affect Incumbent Truck Manufacturers' Business Models

Master of Science Thesis
in the Management and Economics of Innovation Program

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Abstract

Driven by visions of reduced greenhouse gas pollution, the automotive industry undergoes a transformation towards environmentally friendlier vehicles. Emobility (here defined as electric drivelines powered with batteries) is one alternative whereupon the technology now has spread from passenger cars into the truck industry. Previous research in emobility lack insights in what impact electrification might have on incumbent truck manufacturers respectively if and how a commercialization is restricted by current arrangements. This thesis addresses that gap by investigating what affect emobility might have on incumbent truck manufacturers' business model and the potential need of adaptation to enable customers' adoption of the technology. Due to technological maturity, the scope is delimited to focus on the smallest types of trucks and the applications of refuse collection and city distribution.

Naturally, emobility bring changes to incumbent business models. However, this study conclude that these changes primarily takes place upwards the value chain where the size of business model impact depend on certain strategic decisions that truck manufacturers make. Such strategic decisions e.g. include engagement in battery production or providing charging infrastructure. With new investments or acquisitions, truck manufacturers could start to develop and produce their own batteries, which would drastically affect their business model. However, most truck manufacturers purchase their batteries from suppliers or partners, hence only creating a large exposure and dependency to new suppliers. Additionally, insights from interviews indicate that incumbent truck manufacturers rely on external actors or partners to build, install and maintain a fast charging infrastructure, which create more dependency for these companies. Simultaneously, interviews with refuse truck operators indicate that they prefer greater range and night charging, hence making this initial niche market independent from a fast charging network the strategic decision of providing charging infrastructure of less relevance.

Downwards the value chain and towards customers, changes are found to be only minor. Instead, new internal competence regarding electric engines and batteries will be needed as today's core competences, especially regarding combustion powertrains, become obsolete and truck manufacturers transcend to electric powertrains. A growing importance from digital services is expected, which could work as an antidote to lost aftermarket revenue since the electric powertrain create a reduced need of service and maintenance. After analyzing the empirical findings, this study concludes that the existing business model is sufficient for commercializing electric refuse trucks, however with some dependency from political incentives and with truck manufacturers focusing on the total cost of ownership for their customers.

Key words: Electromobility, emobility, electric refuse trucks, incumbent truck manufacturers, business model, business model innovation

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1 Introduction

This chapter introduces the background of the study and problematizes the empirical setting. A small selection of previous research is lightly presented to finally arrive at what gap this study aspire to overbridge. At last, the thesis' purpose, research questions and scope are presented.

1.1 Empirical background – sustainability driving industry transformation

Altogether, transportation accounted for 24% of global CO_2-emissions during 2015, hence making the sector the second biggest producer of the greenhouse gas pollution (IEA, 2017a). Upon dissecting the transport sector, road transport stand for roughly 75% of these emissions and if unchanged, CO_2-emmisions are expected to increase with 33% by 2050 as a consequence of raised oil-demand compared to today's levels (IEA, 2017b). Despite the environmental impact, road freight vehicles remain one of the major enablers of economic activities where economic growth often are positively correlated with increased road freight activity. Consequently, Knupfer et al. (2017) highlight the necessity for automakers and passenger car manufacturers to adapt to tightening policies and shifting consumer demands with raised environment awareness. Since a significant reduction of emissions can be achieved through adoption of electric vehicles, incumbent actors need to consider their strategies for transcending to a technology different from their current (Nealer, Reichmuth, & Anair, 2015).

Despite electric vehicles experienced successful development already in the late 19th century (Burton, 2013), the development for heavier vehicles including trucks and buses has been lagging due to insufficient technology as a consequence of tougher performance demands than passenger cars (IEA, 2017b). But though several manufacturers prepare and announce for a commercialization of electrically driven trucks, several uncertainties remain over a number of factors which create difficulties in predicting and handling the shift from a business perspective (Taefi, Fink, Kreutzfeldt, & Held, 2013). Today, vehicle manufacturers struggles to identify and mediate the profitability in transcending towards emobility to their customers (Petersson, 2018). Simultaneously, the technology and usability depend on several alienage features provided by actors in a system differentiated from the existing one. Suddenly, traditionally essential large socio-technological system components including gas stations, infrastructure providers and service shops risk to become obsolete and a necessary to replace (Tongur & Engwall, 2014).

1.2 Emobility for trucks – A business model question?

Strategies are important for a firm to reach and maintain a competitive advantage over competitors. When talking about companies, corporate and business strategy needs to be separated with the distinction that "*corporate strategy is concerned with where a firm competes; business strategy is concerned with how a firm competes within a particular area of business"* (Grant, 2016, p. 292). A tool for embodying the business strategy are business models which in detail specify *how* the company intend to create, offer and receive value from its customers. Effective and unique business models carry potential to differentiate the produced value and bring competitiveness to a firm – new or incumbent – whereas the models has gained increased recognition as an analytical tool within academic areas as strategic management (Clauss, 2017). By emphasizing the *creation* of value, studies of business models have also gained ground among scholars within innovation management (Tongur & Engwall, 2014).

As Tongur and Engwall (2014) state, *technology shifts* or *discontinuities* (Drucker, 1969) are among the most critical happenings to a successful business, with the fall of the American film and camera producer Kodak as a frequently cited empirical case (Lucas Jr & Goh, 2009). Similarly, the industry of heavy-duty vehicles (from now "trucks") is now transforming where diesel driven trucks, buses and construction equipment are expected to be replaced by emission free electric alternatives. Carrying the status of a potential technological paradigm shift, the transition towards emobility (electromobility, electrically driven vehicles) will have a significant impact on incumbent manufacturers where e.g. existing business models may need to be revised and new strategies created (Quak, Nesterova, van Rooijen, & Dong, 2016).

Going beyond business models and technological innovation, Tongur and Engwall (2014) investigates the *business model dilemma* by emphasizing mature manufacturing companies whose business is subject for a technological shift. Business model innovation then becomes a term referring to innovation of the business model itself rather than a product or service innovation (Baden-Fuller & Haefliger, 2013). "*It is a business model problem, not a technology problem*" (Christensen, 2006, p. 48) put the finger on it by referring to the fact that a technological advancement not always is the best way to cope with a changing environment. Instead, innovating the business model itself might be sufficient or perhaps necessary (Chesbrough, 2007; Tongur & Engwall, 2014).

1.2.1 Previous research and research opening

After reviewing research within emobility for heavy vehicles it's evident that few previous works treat emobility's implication on existing business models for the heavy vehicle segment. Instead, researchers have focused on governmental policy issues or which objectives - both from a sustainability, infrastructural or individual technical component perspective - to undertake for increasing the diffusion of emobility within the truck segment (Arnäs & Karlström, 2013; Gries, Witte, Föhring, & Zelewski, 2014; Taefi, Kreutzfeldt, Held, & Fink, 2015).

Some works combining business models and emobility has however been conducted and are worth highlighting as key references:

- Stålstad and Williander (2013) came up with and evaluated four different potential business models for selling electric passenger vehicles and concluded that incumbent dittos are inefficient for the introduction of electrical passenger cars. To especially overcome a higher investment cost and instead take advantage of lower operating cost, the models was either based on carpooling, leasing or fringe benefits cars.
- Abdelkafi, Makhotin, and Posselt (2013) performed an extensive evaluation of a numerous business model concepts and their applicability or transferability to emobility, though focusing on passenger cars. The authors further observed that most concepts are applicable to only one value dimension, i.e. either value creation, value proposition or value capture which are the fundamental elements for the business model (Clauss, 2017).
- Gaiardelli, Resta, Martinez, Pinto, and Albores (2014) presented an empirical study of an Italian car manufacturer's implementation of services with a strong focus on the value proposition. The authors also distinguished and indexed 30 different types of services to offer a customer.
- Tongur and Engwall (2014) come close to this thesis's purpose in their work where they examine possible business actions for truck manufacturers to undertake in order to prepare for a technology shift. The technological shift the authors emphasize are however towards ERSs (electric road systems) and thereby differentiated from the battery powered trucks which this research scope. The authors conclude their work by stating that both service and technological innovation to a higher level should be considered together when analyzing a firm's value creation. Otherwise and without an edge in terms of value offer, the company will face difficulty to handle future competition.

The selection of works above exemplifies how previous research focus mostly has been turned away from heavy vehicles and instead towards the electrification of passenger cars. Not seldom is servitization also a recurring element in the studies where not least a service-based business model is argued as preferable to overcome high purchasing price as a barrier to adoption. When considering the studies that exist on heavy vehicles and emobility, we therefore conclude that scholars seem to overlook the implication electric trucks might have on incumbent business models once those studied barriers has been resolved. This report target to overbridge the gap and contribute to the body of knowledge within emobility by exploring the potential need for revised business models within the truck segment to leverage the technology's diffusion.

1.3 Purpose

Against the described background and problem analysis, the specified purpose of this study is to bring insights of, and analyze how, the introduction of electric trucks may implicate incumbent truck manufacturers' existing business model. To do so, the thesis propose to understand and investigate customer demands and stakeholders' influence in the innovation system. Altogether, this study strengthens the academic field of business model innovation by providing insights of whether and how new technology may force actors to redesign their incumbent business models or not.

1.3.1 Research questions

The next chapter is the frame of reference for this study. After reviewing each section and theoretical concepts, a related research question for that field is formulated. The four central research questions which the report intend to answer are however listed below for preview:

1. How is the general current business model for truck manufacturers designed today?
2. What interest and role do stakeholders downstream the value chain have in emobility and how may these affect the existing business model?
3. What is the potential for servitization and how would that influence the existing business model?
4. How does the total cost of ownership (TCO) differ between a diesel and electric truck and how does this difference need to be accounted for in the business model?

1.4 Scope

This study focuses on what impacts electrification within the automotive industry might have on incumbent trucks manufacturers' current business model. The thesis does not intend to present applicable business model concepts or recommend which actions perceived necessary to undertake for the focal company to cope with a changing environment successfully. Instead, the target is to provide insights collected from various stakeholders in the system and from that identify what strategic issues that arise respectively how a manufacturer might be affected in general and in his business model in particular.

Through consultation with the cooperating manufacturer, Volvo, the study is delimitated to the smaller types of vehicles which were declared closest to commercialization. With current happenings taken into account, with a newly launched full electric refuse truck in Gothenburg, such a delimitation is perceived highly motivated.

Due to the delimitation of smaller trucks, the study has mainly focused on customers with business within city distribution and recycling with refuse collection. The reader should however be notified that the exact field of application was of less relevance on beforehand when setting the scope. Instead, the selection was made from a number of criteria, primarily technically related. Limited daily driving range, frequent start & stop and operations within an emission sensitive environment are all terms fulfilled by the studied fields of application. The analysis over business model implications is thereby not bounded to these fields of application, but rather for such driving characteristics.

There are several external stakeholders that may influence a truck manufacturer's business model when transitioning towards emobility. Examining all external stakeholders hasn't been feasible during this thesis whereupon delimitations had to be made. This report will focus on insights from customers downstream the value chain and include the political arena, energy companies as well as university insights. It therefore excludes partners and suppliers upstream the value chain such as battery manufacturers.

Geographically, the scope is separated. Collected external stakeholder insights must be regarded as limited to Sweden due to the interviewed individuals' national location. Insights from the manufacturer's perspective are however more international where differences between markets and countries have been found to occur. Consequently, the analysis and discussion will first and foremost treat the business model implication for the Swedish market but occasionally bring an international perspective to either highlight differences or similarities.

1.5 Outline of the report

Figure 1 illustrates the disposition of the report. After above background and problematization follows the study's literature review where theory on business models, network dependency and servitization is presented. Not least is the study's utilized business model framework and its elements laid forward which also will be how the implication on business models finally will be summarized in the analysis. The methodology chapter thereafter explain how the study was conducted and include the chosen research strategy, design and followed process. The chapter also include a discussion over the study's trustworthiness as well as comments on the perceived generalizability and reliability.

A chapter over what changes emobility as a technology brings is provided when moving into *Empirical findings*. Customers' and external stakeholders' perception and attitude to these changes is thereafter investigated and reported in together with the economic characteristics of emobility. In the *Analysis & Discussion*, these findings are first synthesized before used to address the specific research questions (RQs) and reach a conclusion. Structurally, the empirical findings are synthesized in the same sequence as they were presented. Thereafter, the focus is turned towards each research question where the analysis is structured through specific identified key themes relevant for the research question. The business model implication from these key themes are thereafter summarized and highlighted in an illustration which reoccur after each addressing each research question. Lastly, the study is concluded by discussing both findings, managerial implications, theoretical contribution and how our findings contradict previous research.

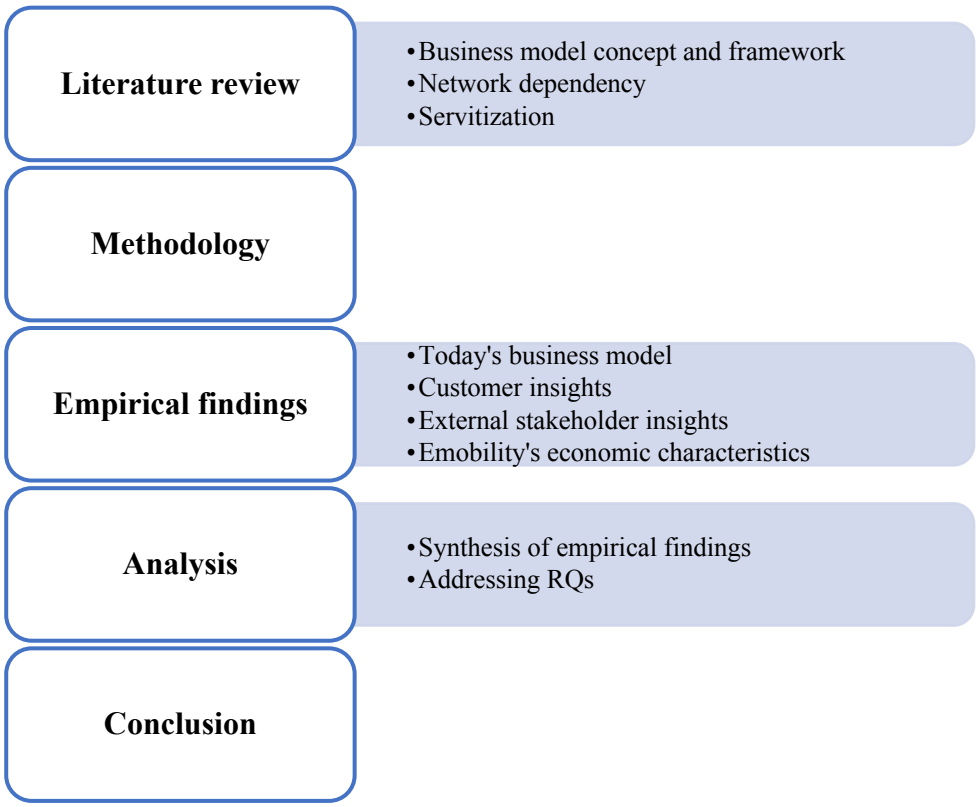

Figure 1: Overview over the outline of the report.

2 Frame of reference

The following section describe the academic fields and frame of reference utilized to guide the research and put the empirical study into a coherence. In the end of each field, a related research question is formulated and argued why necessary to investigate to fulfill the purpose.

2.1 From technological innovation to business model innovation

As declared in the introduction, business model innovation refer to innovation of the business model itself rather than a product or service innovation (Baden-Fuller & Haefliger, 2013). The concept has emerged as a subset to business model design and business model reconfiguration with the essence that firms may compete or penetrate markets with business models differentiated from incumbent actors', after which technological superiority is of less importance (Massa & Tucci, 2013). The list of examples where actors – new or incumbent – has innovated the way of conducting business within an industry is extensive and growing (Chesbrough, 2007), e.g.:

- The European aircraft carrier Ryanair gained a market by signing novel agreements with underutilized airports outside major cities, hence capable of offering cheap flights to leisure travelers.
- GE Aircraft found a way to shift the risk of downtime from the airline customer to GE by selling flight hours rather than jet engines, hence offering a completely new value proposition.
- Xerox reached an industry leading position in the copier business with a business model based on leasing copy machines rather than selling them. More on this case in *2.1.1.1 An example of business model innovation – the case of Xerox.*

As deduced from the examples, many business model innovations maneuvers firms' value offering by either replacing or complementing a core product with services (Baines, Lightfoot, Benedettini, & Kay, 2009). Even more interesting is how the movement span over many different industry boundaries, hence awakening the abstraction of a similar development in the business of trucks. Furthermore, Massa and Tucci (2013) recognize that sustainability-related innovations, either in the company's processes or products, is restricted by a market which seldom rewards sustainability initiatives. Additionally, network dependency or externality surrounding a complex technological system often complicate the opportunities for making profit out of any innovation. As suggested by numerous scholars, business model innovation could overcome such barriers, e.g. by offering service-based products and apply novel revenue streams. Such undertakings would allow for a lower upfront cost for customers which otherwise often is a problem for green technologies (ibid.).

2.1.1 Disruptive innovations and business model innovation

Disruptive innovation theory has been made popular by Christensen (1997a) and have had a substantial influence on the management practice (Yu & Hang, 2010). What Christensen

(1997a) argues is that there are disruptive technologies which are initially inferior to the mainstream technology but possess other values than the mainstream technology. Most often, the disruptive technology has inferior performance and lower price than the mainstream, but with a faster performance development. Not seldom, the performance of the mainstream technology comes to overshoot the expectancy of the mainstream customer which eventually contribute to a technological disruption as the inferior technology more accurately meet the demand from customers (Christensen, 1997a).

It is difficult for companies to defend against this disruption because disruptive technology tends to initially employ business models which go after new markets and customers where margins are lower, and the inferior technology isn't something existing customers are interested in. For incumbent companies, it is much easier and more convenient to improve their existing product and sell it to their best customers for a higher price instead of going after that inferior technology and trying to sell it for a lower margin to a new market. When the disruptive technology eventually is good enough to replace the mainstream technology, it is usually too late to switch (Christensen, 1997a). Classic example of disruptive innovation is the hard drive industry were the transitions from 14-inch disk drives to 8 inches, to 5.25 inch, to 3.5 inch and then to 2.5 inches turned out to be very difficult for the established companies. Figure 2 illustrate how a disruptive innovation can take over the market when the incumbent companies are overshooting the performance perspective and costs are reflecting the performance (ibid.).

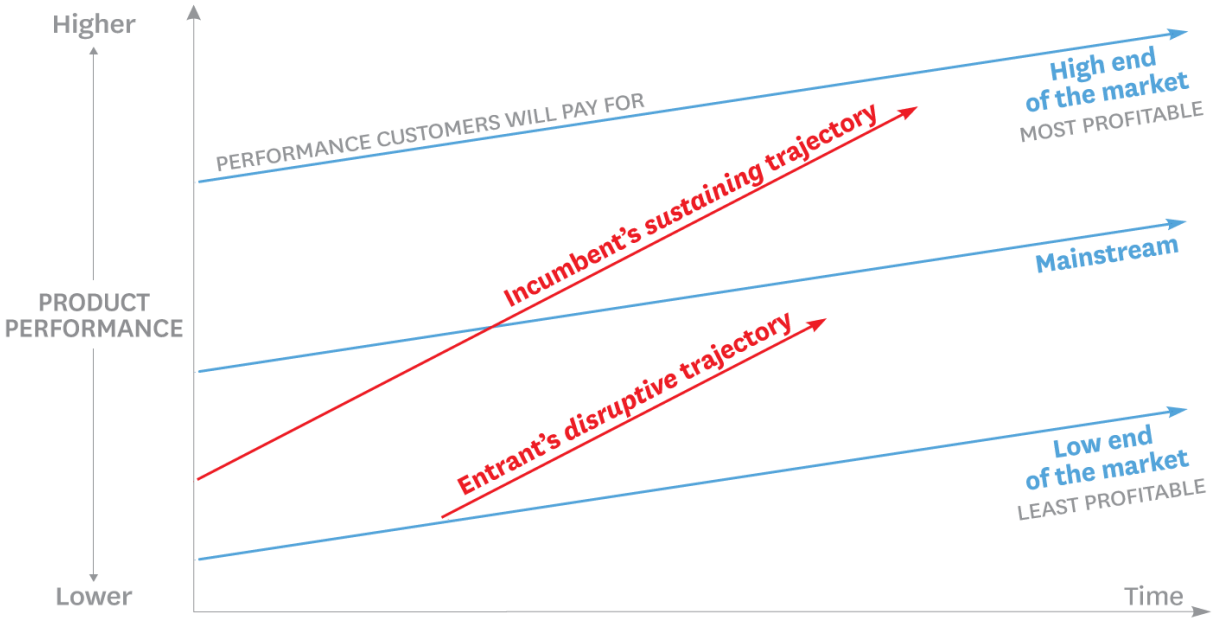

Figure 2: Disruptive Innovation Model (Christensen, Raynor, & McDonald, 2015).

2.1.1.1 An example of business model innovation - the case of Xerox

As previously cited from Christensen (2006) business models and their arrangement may sometimes be the factor hindering inventions to become commercialized. As presented in the background, the history contains several examples where a different business model has given

companies a competitive edge or being able to diffuse new products, meaning that the technology itself wasn't the real problem causing a slow diffusion. One of those cases is the company Xerox who in 1959 had developed and was a ready to launch their new copier model 914 which was able to print high quality images on regular paper instead of needing special paper. The downside was that the printer was incredibly expensive due to a manufacturing cost of $2000. Together with the fact that most companies only made 15-20 copies per day, the American consultancy bureau Arthur D Little rejected the printer's commercial potential due to a nonexistent market. But, instead of selling the expensive machines, Xerox applied a novel service based business model where the copiers were leased to customers for $95 per month. Additionally, customers were charged only 4¢ per print after exceeding a 2000 pages limit. Since Xerox took all the risk and provided all the consumable materials it was not only very easy to find companies to lease to, but the demand for copying also increased and went to average around 2000 copies per day (Chesbrough & Rosenbloom, 2002).

2.1.1.2 Emobility creating new business models in passenger car segment

Before recently announced launches of electric trucks, the emergence of electric vehicles has mainly been restricted to passenger cars. For passenger cars, the development has opened the opportunity to differentiate from competitors with car pools and taxi companies niching themselves by only deploying electric cars (Kley, Lerch, & Dallinger, 2011). Additionally, incumbent car manufacturers are becoming challenged by new entrants who undertake new approaches to electric vehicles. Tesla motor is such an actor who, since 2003 when the company was founded by Elon Musk, have taken their own path and shook up the automotive industry. Though lacking an existing charging infrastructure, i.e. the same issue present today, Tesla has managed to emerge and gain a market leading position in regard to electric cars. Early, executives at Tesla identified the battery performance as the biggest limitation to applicability, whereas Tesla spent a lot of effort to find the best battery and charging infrastructure solution (Van Den Steen, 2014). Now the strategic decision has been taken to invest and build the world's largest battery factory, Gigafactory, with the expectation to drive the battery price down (Gianesello, Ivanov, & Battini, 2017).

Most car manufacturers rely on car dealers to sell their cars. Tesla took another approach when they opened their own showrooms, hence taking inspiration from Apple's strategy. Beyond cutting out the middleman, the main benefit was a tighter control over sales since car dealers often try to sell extra services packs such as oil changes or driveline checkups which electric cars technically have less need for. Tesla sensing conflicting interest with dealers who would have less incentives to sell a Tesla car compared to a Volvo, BMW, Mercedes etc where they could try to sell additional service contracts is an important factor which led to in-house driven showrooms (Van Den Steen, 2014).

In 2017 Tesla announced their planned launch of their first truck - Tesla Semi, hence expanding their business model by trying to break into the truck industry (Sripad & Viswanathan, 2017).

2.2 Business model framework

As part of a firm's strategies (Hedman & Kalling, 2003), business models may abstractly be described as the firm's tool for connecting technological potential to the realization of economic value by creating a logic to follow (Chesbrough & Rosenbloom, 2002). Since a technology or idea itself doesn't possess any inherent value, but depends on the business model to create value (Vanhaverbeke & Chesbrough, 2014), a business model may therefore more tangibly be defined as a construct which "*describe the rationale of how an organization creates, delivers, and captures value*" (Osterwalder & Pigneur, 2010, p. 14).

In literature, business models are commonly explained through various designs and frameworks (Chesbrough, 2010; Johnson, Christensen, & Kagermann, 2008; Osterwalder & Pigneur, 2010; Osterwalder, Pigneur, & Tucci, 2005; Shafer, Smith, & Linder, 2005; Voelpel, Leibold, & Tekie, 2004) where the conceptualization over its included elements and their interplay differ. Reoccurring model-components are however distinguished including value propositions and a financial mechanism accompanied with a customer and supplier aspect. E.g., Johnson et al. (2008) visualize their model as four interlocking elements: value proposition, key resources, key processes and profit formula. The famous canvas developed by Osterwalder et al. (2005) is another commonly cited conceptualization treating *key partners*, *key activities*, *key resources*, *value propositions*, *costumer relationship*, *channels*, *customer segments*, *cost structure* and *revenue streams* as aspects to consider when designing the business. Together, these nine building blocks span over the areas Infrastructure, Offering, Customers and Finances (ibid.). The canvas has been widely adopted and extensively used due to its straightforward design and construction which enable practitioners to easily understand businesses and describe business models.

Based on an extensive review over business model literature, Clauss (2017) propose a framework consisting of three aggregated dimensions: *value proposition, value creation* and *value capture*. Consequently, the customer and supplier aspects has been merged together into one dimension – value creation, while value proposition stand alone and value capture represent the financial mechanism. The three dimensions are however strongly linked to various detailed business model frameworks with its roots constituting of elements proposed by other scholars. Since the empirical case regards an entirely new technological system, it appear motivated to apply a conceptual framework not categorizing the business in only one way as e.g. Osterwalder et al. (2005) canvas, but instead allow to bring as many small elements as possible yet simultaneously enable to aggregately discuss the differences arising with emobility. Since it allow the discussion to go both deep and stay aggregated when necessary, the business model conceptualization provided by Clauss (2017) will be applied to the analysis and constitute the backbone of the study (see Figure 3). To ensure a mutual interpretation over the business model framework, each element is explained below.

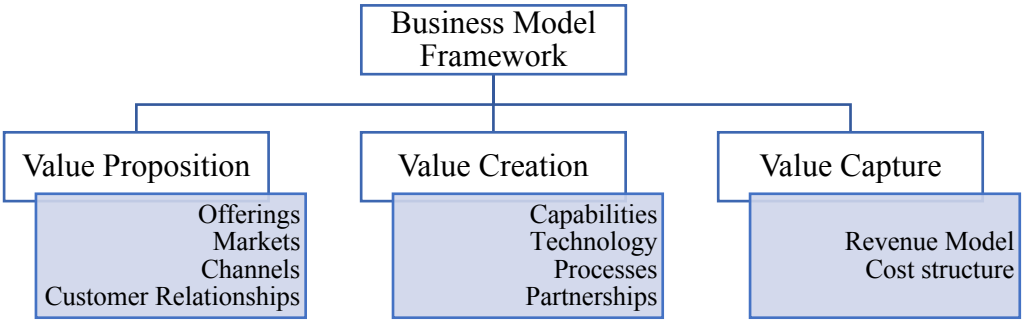

Figure 3: Key elements of this study's business model-conceptualization. Adapted from Clauss (2017).

2.2.1 Value proposition

Value proposition should answer what value you are giving to your customer. Osterwalder and Pigneur (2010) describes the importance of understanding products' or services' importance since it make up the backbone of a firm's relevance. As further declared, businesses "*seeks to solve customer problems and satisfy customer needs with value propositions*" (Osterwalder & Pigneur, 2010, p. 16). Clauss (2017) conceptualize value proposition from four different 2nd order dimensions: Offerings, Customer segments & Markets, Channels and Customer relationship. Each of these have in turn 3rd order elements as shown in Table 1.

Table 1: Content and elements of value proposition. Adapted from Clauss (2017).

1st order	**Value Proposition**			
2nd order	***Offering(s)***	***Customer Segments & Markets***	***Channels***	***Customer Relationships***
3rd order	- Activity system - Platform - Product/service flows - Solutions - Customer benefits - Technologies to be embedded into products and services - Value - New products and services - Value is generated - Job to be done - Output - Offering	- Target markets - Positioning - Target customer - Market/ customer segments - Presence	- Distribution channels - Value delivery and linkages - Value chain to create and distribute value	- Customer engagement - Customer experience - Customer relationship - Branding - Marketing and sales logic

2.2.1.1 Offering(s)

The offering(s) itself are one of the most important core parts of a business model since it defines what value the firm offers to their customers or what need they satisfy (Johnson et al., 2008). Consequently, companies constantly need to evaluate their offerings and what value they supply their customers in order to remain relevant. This often imply constant innovation to find

new ways of solving customers' problems (ibid.). Today, this frequently comes from technology, but one has to be cautious to not just deliver a technical solution since these devices or components in itself seldom aren't a great solution for the customer. To provide a great solutions often require a bundle of services in accordance to the devise or component (Teece, 2010). Changing or broadening your offering can thereby mean large internal changes for the company. Simultaneously, the larger the share of value a company deliver to its customer, the more they can generally charge (Clauss, 2017).

2.2.1.2 Customer segments & Markets

Customer segments and markets defines which customers and/or markets the company intend to do business with and consequently compete on, both now and in the future. Consequently, a company need to understanding who is prepared to pay for your offerings (Baden-Fuller & Haefliger, 2013; Teece, 2010). Historically, customers have paid for the product or service they want but where today's technology have enabled more complex constructions. There are several examples of markets that aren't paid by the users, but instead by advertisers. YouTube and Facebook are great examples of such so called two-sided platforms (Rochet & Tirole, 2006). Two-sided platforms bring a new and difficult aspect, were you both have to satisfy the users as well as the advertises and their opinions may not be alien (ibid.).

2.2.1.3 Channels

Companies can use different channels to deliver the value to its customers which affects the value proposition to its customers. There are several ways companies can distinguish their value delivery. Classic examples are direct-to-customer distribution channels without the need for retailers. This is something that Dell successfully has built upon (Johnson, 2010). Other ways that are common today are "bricks and clicks" business models where a firm combines an online and an offline distribution channel (Clauss, 2017). As an example, Apple and Tesla have built up showrooms where they can promote and show the product in the best possible way while they have full control.

2.2.1.4 Customer relationships

The customer relationship a firm has with its customers may have big impact on its business. What stage the market is in, how mature the product is, and current competition are all parts that affects how important customer relationships are and what type of relationship that is most suitable. Having a good relationship with your customer can give you an edge compared to your competitors were you otherwise were forced to compete on price, which can be very critical in a mature market. Customer relationships can also be an important source of feedback (Clauss, 2017).

2.2.2 Value creation

Value creation is the second of the three subdimensions that Clauss (2017) define. This subdimension in turn consists of several secondary dimensions, Capabilities, Processes and

structure, Partnership and Technologies & Equipment which in turn constitutes of additional elements as illustrated in Table 2.

Table 2: Content and elements of value creation. Adapted from Clauss (2017).

1st order	**Value Creation**			
2nd order	***Capabilities***	***Processes & Structures***	***Partnership***	***Technologies & Equipment***
3rd order	- Core competency - Capabilities - Key activities - Leadership capabilities - Information - People - Resources and competences	- Activity system governance - Activity system structure - Internal and external structures and processes - Internal and external organization - Norms - Organization - Processes - Resource velocity - Rules and metrics - Value configuration	- Customer Information - Internal and external organization - Key partners - Networking - Partner network - Partnerships/ alliances - Suppliers - Supply chain - Value chain to create and distribute value - Value network	- Key resources - Resources - Technology - Equipment - Resources and competences

2.2.2.1 Capabilities

"*Firms need to utilize and develop new capabilities that enable them to use opportunities that arise from the external environment*" (Clauss, 2017, p. 392).

Capabilities are developed through different means such as training and seminars (Clauss, 2017). The learning aspect is important, and firms are recommended to provide an environment for their employees to freely experiment and try new ideas where failures and mistakes are viewed as learning lessons (Achtenhagen et al., 2013). A case which Achtenhagen et al. (2013) refer to is the Swedish bread company Polarbröd who made several mistakes when they tried to enter the German market, but since they continued to attend fairs they managed to develop a successful strategy and enter the French bread market successfully.

2.2.2.2 Processes & Structures

Processes and structures help link processes and activities, but can also be a basis for business model innovation since new processes and/or structures can produce a need or opportunity to rethink the business model (Clauss, 2017). As an example, Zott and Amit (2010) bring up IBM that in the early 1990s transitioned after several financial problems from their core as a hardware provider to become a service provider. They started to offer IT maintenance, consultancy activities etc. and 15 years after the introduction, these new services stood for more than 50 % of IBM's $90 billion revenue in 2006.

2.2.2.3 Partnerships

Partnership represents external resources that a company can utilize. These external resources are not seldom essential for companies who can't manage all resources that they need within the company (Clauss, 2017). Companies today often need several types of different knowhow and knowledge which may be difficult to organize in-house, whereas creating alliances are a great way of solving such issues. Bierly III and Gallagher (2007) identify three parts. The first is the strategic fit which is a very important issue but cannot in most situations be used in the selection process. The second part discussed is trust and uncertainty, arguing that the more difficult and uncertain something is, the more critical trust becomes, even though it has no guaranties. The third part that makes it difficult to create a good partnership is time and the lack of it. When there is a time pressure for executives, it is more difficult to take rational decision with well-considered decision-making processes. Instead, reliability is put to intuition (ibid.).

2.2.2.4 Technologies & Equipment

When new products or services are introduced they may require new investments in technology that is suited for the new product or service. In the same way introducing a new revenue model can require new technical systems for payment etc. (Clauss, 2017). The importance of aligning technological development and equipment with the company's overall goal has become even more important today, something that studies by Wei, Yang, Sun, and Gu (2014) shine light upon in their investigation over technological innovations' fit with business model design at Chinese firms.

2.2.3 Value capture

Finally, value capture is the last of the 1st order dimensions and consists of two 2nd order dimensions, *revenue models* and cost *structures*. As with previous 2nd order dimensions, they consist of several 3rd order dimensions that can be seen in Table 3 below. Understanding and designing your value capture is key since it structure how the company capture value in form of monitory terms.

Table 3: Value Capture (Clauss, 2017).

1st order	**Value Capture**	
2nd order	***Revenue models***	***Cost structures***
3rd order	- Revenue model - Revenue streams - Revenue/pricing - Revenue mechanisms - Profit formula - Monetization - Estimation of cost structure and profit potential - Volume and structure of revenues	- Cost structure - Estimation of cost structure and profit potential - Financial hurdle - Margin model - Volume and structure of costs

2.2.3.1 Revenue models

Revenue models concerns how customers are going to pay for the value proposition. Historically this has been the monetary exchange when the customer buys the goods, but with firms transitioning towards services instead of one-time payments, the revenue models are also changing. Firms today have to ask themselves when the value is generated, how is it generated, by whom and are there any additional review stream created during the life cycle (Clauss, 2017).

2.2.3.2 Cost structures

Cost structure on the other hand focus on the complex cost structured within the company, when is the cost generated, by what processes. These need to be aligned with the offering(s) the company has. Here (Clauss, 2017) uses Ryanair as an example of a company that needed to change its cost structure to match the corporate strategy. As a low-cost carrier, they've cut their costs throughout the business.

2.2.4 Formulating research question 1

This study purpose to emphasize what changes electric trucks may bring to existing business models of truck manufacturers. To enable such a purpose fulfillment, an understanding and description over current business models is necessary to allow for a comparative analysis. The first research question to address is thereby formulated as:

How is the general current business model for trucks designed today?

2.3 Network dependency – the influence of value networks and business ecosystems

Retrieved information and previous research on emobility imply that the technology figurate in a system dependent on other actors to function or diffuse. Consequently, theory about network dependency including business ecosystems and network value chains is included in the frame of reference and later utilized throughout the analysis.

A fundamental requisite for companies to reach and conserve competitiveness is to create more value than competitors and indirectly its ability to innovate (Porter, 1985). Simultaneously, innovations' and firms' success commonly depend on accompanying changes and new actors in the surrounding environment, i.e. so called complementors (Adner & Kapoor, 2010). Value created within a system is treated through various academic fields including e.g. *business ecosystems* and *value networks* (Mäkinen & Dedehayir, 2012). In literature, the latter often refer to the supply chain of a provided product or service with Christensen (1997b, p. 296) defining value networks as *"the collection of upstream suppliers, downstream channels to market, and ancillary providers that support a common business model within an industry"*. Allee (2003, p. 192) widen the concept and define a value network as "*any web of relationships that generates both tangible and intangible value through complex dynamic exchanges between two or more individuals, groups or organizations*", hence recognizing a situation in the value chain where an actor's offering creates value only if supported by another actor's.

According to Lusch, Vargo, and Tanniru (2010), value networks are becoming more frequently emphasized and spread internally in firms as the companies' offerings are shifted towards services. Consequently, previously considered value chains are replaced by a value network-view in such firms. By studying the ongoing transformations in the telecommunication industry, Li and Whalley (2002) empirically investigated such a situation where new customer expectations followed by new business opportunities forced incumbent actors providing services and infrastructure to revise their business models and take radical strategic decisions for the future. The result was a web of actors who sought to provide integrated solutions to each other all the way down to the end consumer. Consequently, the competitive environment has also shifted from rival actors to entire systems competing with each other (Li & Whalley, 2002).

Mäkinen and Dedehayir (2012, p. 1) define business ecosystems as *"the network of firms, which collectively produce a holistic, integrated technological system that creates value for customers."*. Thereby, business ecosystems' resemblance and relation to value networks is distinguishable although value networks emphasize the supply chain perspective to a higher extent. The business ecosystem approach on the other hand include complementary goods or services downstream the value chains more distinctly and emphasize that challenges faced by complement producers may restrict end costumers to fully benefit from the focal firm's product or services, hence missing targeted value propositions (Adner & Kapoor, 2010).

Working with cooperation's in a network can leverage the offered value to customer than ever possible for the individual firm create alone (Mäkinen & Dedehayir, 2012). To achieve such benefits, Adner (2006) propose three strategic considerations to undertake for the focal firm:

1. Resource allocation – where is the bottleneck hindering the innovation located? If the bottleneck isn't internal but instead externally, investments addressed to partners and complementary technologies may be more effective than into the own project.
2. Timing – is the new technology right in time? Innovators need to consider the feasibleness of its products if heavily dependent on complementary advancements. An example is the HDTV technology where TV producers too early invested in high definition technology without realizing that broadcasting equipment was far behind.
3. Risks – how to structurally assess risks in a systematic way? Here, Adner (2006) identify three risks to regard: initiative risks, interdependence risks and integration risks. Together, the risk areas encourage managers to: (1) evaluate common risks with managing and deliver projects within time, budget and scope (2) evaluate the collaboration partners ability to deliver their contributions and (3) evaluate the likelihood of successfully being integrated in subsystems in the ecosystem, particularly towards the end-customer (i.e. downstream the value chain).

The risk considerations enable executives to set the company's innovation strategy and decide whether to allocate more resources in their own activities or support a partner, take part in lobbying or reconsider the target market (Mäkinen & Dedehayir, 2012). Another option is whether to vertically integrate or not, i.e. move along the value chain - either closer to the end customer or upstream and act as a supplier to other actors - or undertake a greater share of the chain's activities itself. Key benefits with vertical integration and control over larger part of the value chain include a mitigated jeopardizing when co-investing with suppliers in assets under uncertain conditions (Williamson, 1985). These uncertainties include technological uncertainty, i.e. if the supplier will be able to develop solutions to future challenges, and behavioral uncertainty, i.e. the risk of suppliers behaving opportunistically with time as a consequence of high level of integration, dependency and switching cost for the focal firm (ibid). While technological uncertainties are reduced with time but not necessarily decreased by vertical integration, behavioral uncertainties can be reduced by increased control upstream the value chain but aren't automatically decreased by time (Adner & Kapoor, 2010).

2.3.1 Formulating research question 2

Initial talks and received understanding dictates that a commercialization of electric trucks may be dependent on external stakeholders. Not only by complementary products such as charging infrastructure, but also through political initiatives which in one way is confirmed by the heavy emphasis previous research has put on the technological system. Investigating these stakeholders' interests and perceived role in the system is therefore regarded as necessary to evaluate the business model effect for the studied application area. As stated in the scope, this study focuses on insights from actors downstream the value chain and will thereby not present any insights from stakeholder upstream the value chain, hence excluding insights from battery suppliers. The battery aspect will still be treated in the analysis. The research question spells:

What interest and role do stakeholders downstream the value chain have in emobility and how may these affect the existing business model?

2.4 Servitization

Early information indicates a potential scenario where current aftermarket revenue are being reduced and the new technology difficult to add big margins to due to low value adding by manufacturers. Consequently, profit margins become threatened whereupon new means to grow is necessary. The theoretical framework therefore includes literature on servitization to allow an investigation and discussion over services potential in the industry and sales of electric trucks.

Servitization, *Servitization of business* and *From product to service* are all appellations of the same phenomena in the field of business model innovation, i.e. the increased comprising of services as value offering from firms alongside their core product (Vandermerwe & Rada, 1988). The rationale behind such actions are naturally economical and function as an antidote to decreasing or threatened profit margins as a consequence of increased global competition (Verstrepen, Deschoolmeester, & Van den Berg, 1999). Though not self-evident, it's becoming more and more difficult to imagine a manufacturer's competition strategy, especially innovator, not involving any services at all. In practice, servitization mean that the manufacturer considers the value chain of its products and undertake a higher level of vertical integration. Most often, the manufacturer look downstream in the chain, i.e. towards the customer, to identify opportunities of service offerings (Wise & Baumgartner, 2000).

By carrying servitization-driving characteristics including e.g. disloyal customers and market saturation, the automotive sector is an industry where services has become common elements in the manufacturer's daily business (Verstrepen et al., 1999). In most cases, such services correspond to after-sales support, training or financing services (Baines et al., 2009) which create opportunities for differentiation and protection of financial margins (Verstrepen et al., 1999). After sales-services are also important tools enabling manufacturers to prepare themselves and customers for future technological advancements and innovations. An example is the American electric car manufacturer Tesla Motors who have prepared their Model S with software ready for autonomous drive, meaning that when autonomously driven cars become a reality, the company can wirelessly upgrade the car for the customer as a service (Mahut, Daaboul, Bricogne, & Eynard, 2016).

2.4.1 Formulating research question 3

As later on discussed in the empirics, the technology of emobility indicate lost revenues for manufacturers' aftermarket and a deprivation of today's core business – the driveline. With services and servitization as a buzz word penetrating most industries and gaining more significance for companies as a mean to grow or even remain relevant, it is perceived motivated to investigate what role and significance services may achieve from the introduction of electric trucks. Research question number three is therefore formulated as below:

What is the potential for servitization and how would that influence the existing business model?

2.5 The concept of total cost of ownership

Much of this study's emphasis will be paid to the concept of total cost of ownership (TCO) were empirical findings indicate to play a key role for truck manufacturers, not least as a performance parameter evaluated by truck manufacturers' customers. Consequently, the concept of TCO can influence manufacturers' business model, e.g. as how they design their offering to reach a positive TCO for customers or key processes performed to help customers understand the TCO benefits with emobility. The fourth and last theoretical field of reference is therefore dedicated to present and explain the concept. As previous structure, the subchapter finish with the formulation of a relating research question.

As a consequence of more sophisticated supply chains in manufacturing with Just-In-Time deliveries and focus on value adding, suppliers are becoming more and more integrated with their customers. Supplier's performance therefore have big impact on its customers whereupon long-term partnerships are being established to share costs, benefits and expertise (Bhutta & Huq, 2002). Naturally, the choice of suppliers increases in importance while much emphasis contradictory remains on the price tag when faced with a purchasing decision. However, the concept of TCO is gaining more and more recognition, both practically within firms' purchasing functions as well as in literature on supply chain management. The term is used to define and describe "*all cost associated with the acquisition, use and cost of a good or service*" (Ellram, 1993, p. 3).

Application of a TCO model mean that the purchaser looks beyond the purchasing price and instead include the cost of doing the transaction as well as costs emerging both pre- and post-transaction. By doing so, costs for capital equipment such as maintenance, repair, expected downtime and disposal are being included in the evaluation which not seldom grows significant during equipment's life cycle. Additionally, costs for identifying needs and make acquaintance with the supplier are being recognized. Two of the benefits Ellram (1993) highlight that an implementation of TCO generates are:

1. *Insights & Understanding* which include several benefits such as excellent data for trend analysis on costs, data for comparing supplier performance, material for negotiations and critical data for target pricing.
2. *Support for Continuous Improvement* mean that the emphasis on TCO helps identifying cost saving opportunities as well as helping suppliers to direct their improvement focus.

Despite more integrated value and supply chains, research on TCO indicates a fairly low implementation rate. As emphasized by Ellram (1993), TCO-modelling is both complex and resource demanding as it require continuous data updates and monitoring which might explain the slow diffusion. Additionally, Bhutta and Huq (2002) identify the lack of standardized approaches to TCO and potential internal resistance of adapting to the total cost-mindset as factors obscuring the implementation.

2.5.1 Formulating research question 4

Early information in the study indicate the TCO as a central element when involved in a truck purchase. With the concept of TCO and its meaning described, this study target to first investigate how the TCO differs between an electric and diesel truck. Thereafter, it is investigated how interviewees perceive these differences before theorizing how inputs and changes affect a business model. The fourth and last research question is formulated as below.

How does the TCO differ between a diesel and electric truck and how does this difference need to be accounted for in the business model?

2.6 Conceptual framework

The theoretical concepts treated in during this chapter is gathered in Figure 4 as a conceptual framework which will be the analytical underframe for interpreting the study's empirical findings. The figure further illustrates how each research question contribute to fulfilling the purpose and what theoretical field in the frame of reference it mainly originates and refer to.

Briefly explained, empirical findings and insights will be brought in to address the study's research questions. Through the lens of relating theoretical concepts, the research questions and their implication on the value dimensions in the business model framework will be investigated. By doing so, the understanding of how each value dimension is being affected by emobility fulfills the study's purpose.

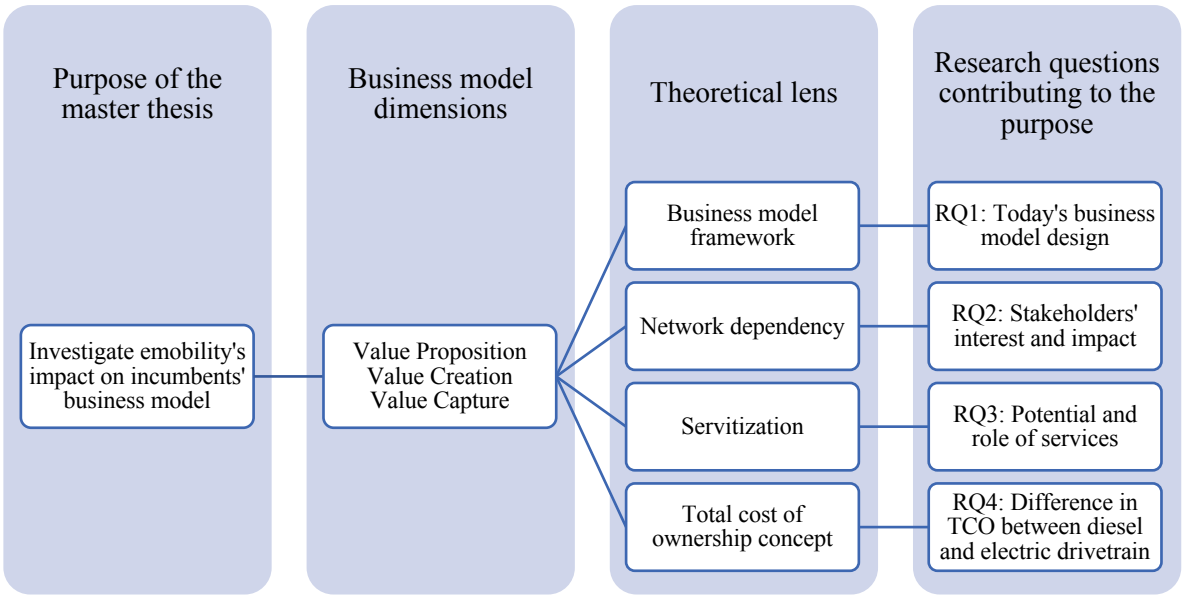

Figure 4: The conceptual framework over theoretical fields employed in the study.

3 Methodology

This chapter describes the study's research strategy, utilized methods for data collection respectively the study's layout and followed process. Undertaken commitments or actions for achieving validity, reliability and generalizability are discussed continuously when applicable. The chapter is finalized with a discussion over the study's trustworthiness.

3.1 Research strategy – a qualitative case study approach

Since the empirical setting and problem analysis didn't involve or state any predetermined hypotheses to be tested with statistical tools, but instead targeted to explore new opportunities in a transforming industry, an overall study design of inductive and qualitative character was chosen as most suitable. The choice is strengthened by Easterby-Smith, Thorpe, and Jackson (2012) who argue that qualitative studies are appropriate when the purpose is to enhance knowledge and generate ideas within a particular bounded context.

Qualitative research strategy involves several general main steps. One of the earliest is to choose a research design to follow. With strengths including "*ability to discover a wide variety of social, cultural, and political factors potentially related to the phenomenon of interest that may not be known in advance*" (Bhattacherjee, 2012, p. 43), a case study approach was judged suitable to answer settled research questions and fulfil the purpose. In practice, the case study imply an in-depth study of one or more objects in its existing context or environment (Bryman & Bell, 2014). A case study further allows an in-depth analysis from a small sample (Easterby-Smith et al., 2012), hence allowing the study's purpose to be expanded though a restricted timeframe. In this study, such a setting has been emobility and its commercial entrance into the truck industry. Studied objects have been small-size trucks within the application field of city distribution and refuse trucks geographically bounded to Sweden.

Lacking generalizability and difficulties to replicate are two common critics facing qualitative researchers and their studies (Bryman & Bell, 2014). However, generalizability may be divided into two categories, internal and external where the first refer to the study's generalizability *"within the community, group or institution studied to persons, events and settings that were not directly observed or interviewed"* (Schofield, 2002, p. 53), whereas the latter refer to generalizing to other communities, groups or institutions. As a consequence, internal generalizability is commonly prioritized in qualitative research (ibid.).

The criticism of lacking replicability bottoms in the argument that qualitative research is highly subjective by nature where high amounts of data opens up for the researcher's interpretation (Bryman & Bell, 2014; Easterby-Smith et al., 2012). Critics argue that such studies are unstructured and reliant on the researcher's cleverness to decide which aspects to focus on and which leads to follow during the study. A lack of standardized procedures to follow and high influences of inter-personal relationships between participants and the researcher is also arguments brought forward as negatively affecting the generalizability of the study results (Bryman & Bell, 2014).

To decrease that criticism's applicability to our case study and instead increase the validity of our results, the reasoning of Yin (1994) was adopted whereupon a design and process was produced prior to any data collection. The process suggested by Bryman and Bell (2014) (see Figure 5) was accepted (though with minor intention to conceptualize or theorize) and constituted the study's backbone which structured both the process and sequences, hence making the study less arbitrarily designed and more replicable. Furthermore, the conceptual framework and frame of reference utilized is considered generalizable, especially within the automotive industry or cases of similar characteristics, as the included literature is highly actual or advancing within the context. Therefore, the prioritized internal generalizability is perceived to have been attained.

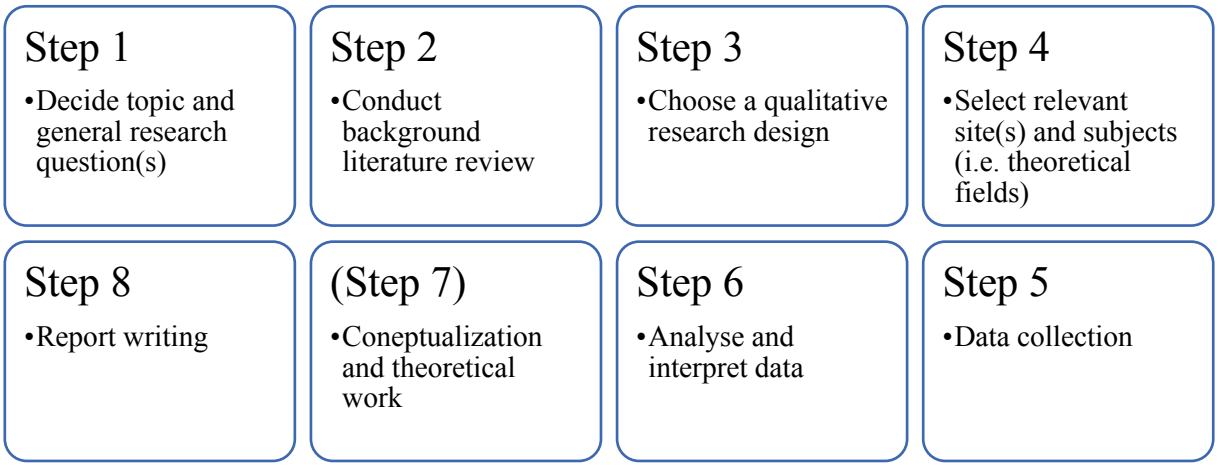

Figure 5: Outline over main steps in the qualitative research. Adopted from Bryman and Bell (2014).

3.2 Research process and linkage to research question

The adopted general process for qualitative research as visualized in Figure 5 may be translated as the process illustrated in Figure 6. The process explains more concretely and in detail how, respectively in what sequence, the study was performed. Each stage's title, included activities and outcome is listed. Additionally, the linkage to formulated research questions and when they were treated is declared.

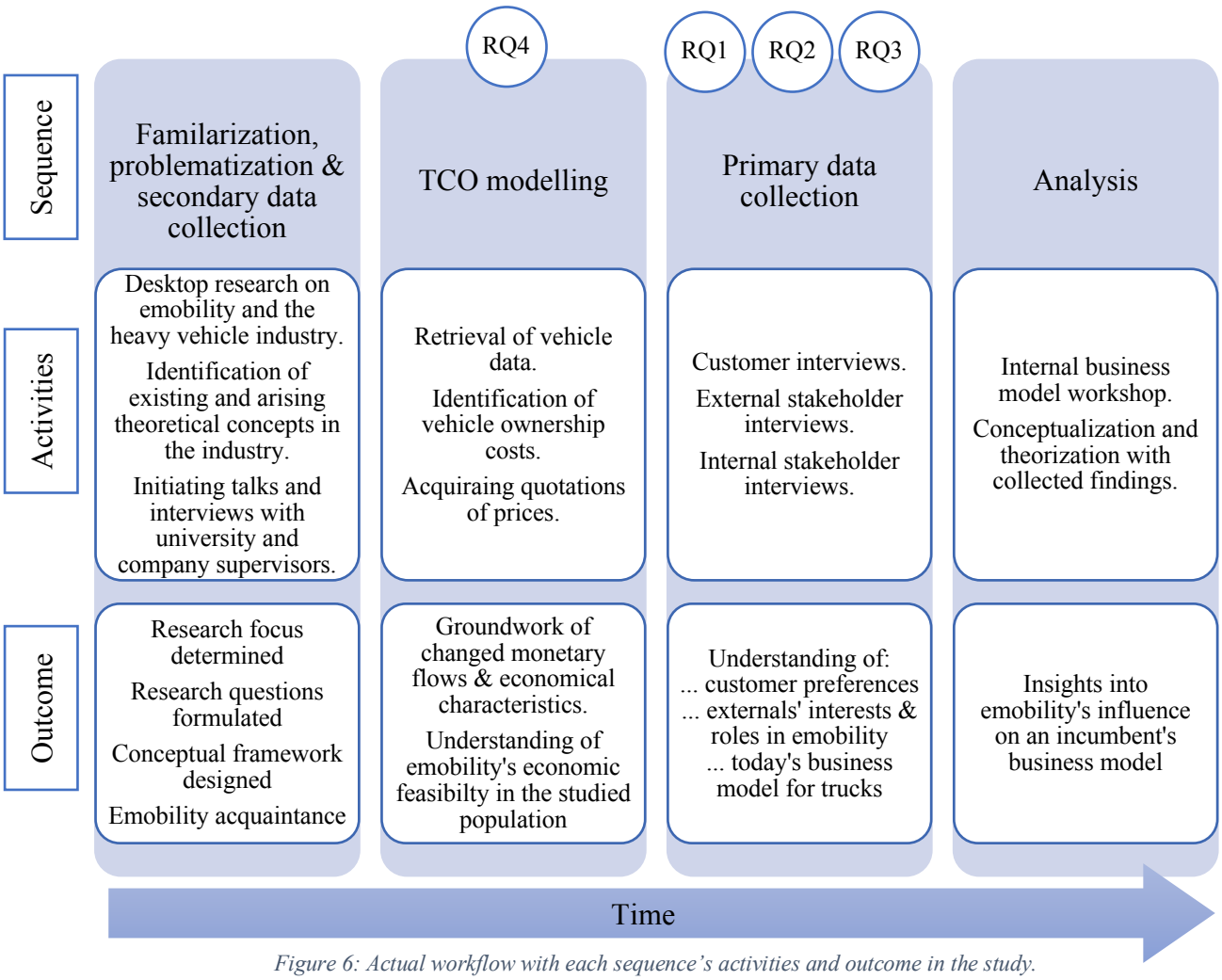

Figure 6: Actual workflow with each sequence's activities and outcome in the study.

3.3 Information gathering

This subchapter describes the methods utilized for collecting data and provide the study with information. Additionally, the type of data and how the quality has been ensured is declared.

When selecting interviewees, relevance for settled research questions and scope where considered and came to include representatives from the focal company, scholars, politicians and infrastructure providers. Since previous studies on emobility indicate that the electrification to a high extent depend on factors outside the focal company's boundaries, the involvement of external stakeholder was perceived necessary to include as many perspectives as possible into the analysis. Naturally, potential customers, i.e. vehicle clients in general and refuse truck operators in particular was also listened to. Aligned with the reasoning of LeCompte and Goetz (1982) the internal reliability is considered to have been strengthened since both authors of this report participated and subsequently listened to recordings of interviews and jointly wrote and revised the report.

3.3.1 Literature review

Our study has not applied a systematic literature review which otherwise is regarded as a highly replicable, scientific and transparent process (Bryman & Bell, 2014). Instead, a narrow and more iterative review over the concept of business models where initiated and thereafter broadened throughout the project. The expectation and rationale were to avoid excluding any potential outcomes or leads prior to any data collection and analysis had been done. Consequently, theory on network dependency, servitization and TCO were added as we learned more about the industry and its challenges. The method was also perceived aligned with the entire study's inductive approach and objective to generate understanding and theory from the empirical case.

Operationally, the information gathering started with a brief literature review to become familiarized with both the empirics and previous writings. First, the search was focused towards the vehicle industry and emobility to problematize the current empirical situation. Secondly, once the business model issue was established, publications of business model concepts and business model innovation was read and mapped. During this sequence, the writers discovered that a uniform definition and widely accepted approach to the concept is lacking among scholars. Instead, the conceptualization and view on which elements to include vary greatly. Finally, the conceptualization presented by Clauss (2017) based on existing business model-literature was adopted with the rationale of including and consolidate most perspectives and aspects otherwise fragmentally presented in previous publications. Consequently, a mutual understanding and definition between the writers was ensured together with an almost completed business model framework.

The initial literature review and first meetings with our company supervisor further pointed out two additional theoretical fields of relevance - network dependencies and servitization. The rationale behind the perceived relevance was the concepts' recurring figuration in business

model literature in general and automotive industry in particular. Additionally, the writers perceived the framework from Clauss (2017) insufficient to address such circumstances and issues. Eventually, the key theoretical concepts were assembled into a conceptual framework (Figure 4 in *2.6 Conceptual framework)*, which constituted the theoretical foundation for observing, analyzing and explaining the empirical data and results.

Though the literature review resulted in a sufficient framework, publications and writings has been iteratively reviewed throughout the study to expand the frame of reference. Supporting or contradicting previous findings and arguments to complement the analysis has thereby continuously been sourced.

Books from Chalmers library has constituted a smaller part of the literature review while the absolute majority of references has been retrieved from searches on Google Scholar or in the online database of Chalmers library. Key words during the online search included: *business model, business model innovation, value network, business ecosystem, business model canvas, business models for electromobility, electromobility and heavy vehicles, servitization.*

3.3.2 Secondary data

Secondary data, i.e. data previously collected by others, not seldom with a general and non-specific purpose (Bhattacherjee, 2012), were mainly collected during the project initiation, problematizing and literature review. Already existing information was however iteratively searched and continuously added to either complement or compare primary data throughout the study. The secondary data were mainly of empirical character and gathered to understand the macro context, the emobility technology, the industry, actors' actions or strategic courses.

Data and literature were exclusively found through online search engines and sourced from online management journals and publications. The credibleness of the literature was primarily ensured by using the search functions Google Scholar and Summon (Chalmers library's search service) then evaluating and examining the source reliability and credibility from an academic perspective.

Secondary data was also received to set up a TCO model and enable the experimentation of different scenarios and their impact on the ownership cost for a truck owner. The modelling further purposed to create a groundwork for economic reasoning and shifting monetary streams through an authentic set of vehicles. This secondary data was sourced from Volvo's fleet management system, Dynafleet, and constituted of authentic logged vehicle data with information about each vehicle's driving history. Accessible and retrieved parameters where on daily basis and included e.g. fuel consumption, driving distance, driving speed, start & stop time etc., both on average level and with standard deviation.

To enhance the reliability and quality of the data, the extractor employed conditions in the data script to avoid poor data. Examples of such conditions was that the vehicle had to been driven more than 10 km to count as a driving day. Additionally, each truck had to have more than 10 days of valid driving data to be invaded in the modelling. This was done to eliminate misleading

and non-representative data. Consequently, situations where a vehicle only was moved on the parking space respectively extraordinary unique driving patterns was reduced significantly.

To be able to setup the TCO model and execute the calculations, quotation of prices was needed. The main source was individuals at various departments on Volvo and included costs regarding e.g. chassis price (excluding battery), maintenance need and its costs. Additionally, specific information regarding the emobility-technology was retrieved and included available battery sizes, current price and prediction (USD/kWh) together with both costs and possibilities to charge the vehicles. While the information first mentioned was highly internal and difficult to source elsewhere, the information regarding batteries and charging was double checked and verified with literature and industry reports.

3.3.3 Primary data

Qualitative data is a self-evident feature of qualitative studies targeting to understand, discover and explore opportunities in an certain environment (Bryman & Bell, 2014). Such qualitative data may be collected through e.g. interviews or observations (Bhattacherjee, 2012) and has been the study's major source of primary data. Multiple qualitative interviews, either on a semi- or unstructured basis where the researchers explored topics in depth (Bryman & Bell, 2014) were held with various individuals throughout the process. Altogether, 16 interviews were conducted, distributed over three stages with different objectives and purposes as declared in Table 4 and Table 5 below.

Table 4: Interview stages, their purpose and expected outcome.

Stage	*Purpose*
1	Generate an initial broad understanding over the focal company, the industry it operates in and the technology in focus.
2	Explore customer preferences and collect aspects from actors in the network to bring into the analysis.
3	Understand and map the current business model in use.

The first stage involved an initial familiarization of Volvo, its scope of practice, customers and industrial challenges. The interview sessions were informal, unstructured, explorative and conducted with minimal preparation during the project initiation and process of empirical problematizing. The perceived most important outcome from these talks where the agreement over the study's scope and delimitations to include city distribution and primarily refuse trucks. The interviewees in stage 1 included representatives from various functions within Volvo as declared in Table 5. The involvement of several company stakeholders has been perceived as a strength since it minimizes the risk of retrieving subjective information from personal interpretations of the interviewee (Bhattacherjee, 2012). Concurrently, the information provided at this point was cross-checked with existing literature to identify a gap where the specific emobility case for refuse trucks could contribute to the scientific body of knowledge.

Table 5: Declaration over conducted interviews sorted by stage.

Stage	*ID*	*Title*	*Date*	*Time*	*Company type*
1&3	I1	Chief engineer	Continuous	N/A	Focal
	I2	City mobility director	18-02-05	30min	Focal's sister company
	I3	Senior feature specialist	18-04-04	60min	Focal
2	I4	Founder and CEO	18-03-07	45min	Recycling
	I5	Fleet manager	18-03-12	28min	Recycling
	I6a I6b	Chief of transportation Vehicle expert	18-03-19	36min	Recycling & Transport
	I7	Purchase and property manager	18-03-21 18-03-23	33min 17min	Recycling
	I8a I8b	1. Chief of transportation 2. Team leader transportation group	18-03-23	40min	Recycling
	I9	Chief of development	18-03-26	46min	Recycling
	I10	Branch manager	18-03-02	56min	Distribution
	I11	Quality & Environmental Manager	18-03-14	27min	Distribution
	I12	Associate professor automatic control engineering & electric vehicle specialist	18-03-12	40min	University & research center emobility
	I13	Emobility specialist	18-03-13	56min	Interest group energy industry
	I14	Juryman public transport VGR	18-03-21	36min	Politics
3	I15	Strategic planner	18-04-04	51min	Focal
	I16a I16b I16c	Product director Business solutions director Safety director	18-04-10	53min	Focal's sister company
	I17	City mobility finance director	18-04-13	75min	Focal's sister company

Supported with guidance from both literature and the interviews in stage 1, potential interviewees for stage 2 were identified and contacted. The criteria for being considered relevant for the study was if the interviewee represented a company performing any refuse collecting or city distribution activities plus were suspected to possess insights to the company's vehicle strategy. The initial interviews and literature review also shined light upon several novelties for the heavy vehicle industry including an entirely new web of actors needed to support the technology. Aligned with these findings, meetings with additional stakeholders were booked to bring in a wider spectrum of perspectives on the topic. These stakeholders included representatives from the politics, university research community and electric companies' interest organization.

The interviews of stage 2 and 3 where held in the format of in-depth semi-structured, meaning that the researchers targeted to find out more details and bring aspects of problems to the surface within certain pre-decided areas of interest, while simultaneously letting the respondent descant within the topic (Bryman & Bell, 2014). These areas stemmed from the initial information gathering with close relationship to the business model framework and included questions regarding: (1) perceived value propositions with electrically powered trucks, (2) the arrangement regarding ownership of the vehicles, (3) possibilities of redesigning the own business and optimize to benefit electric trucks, (4) the service arrangement around existing vehicles today, (5) perceived barriers and success factors to adopt electric trucks as a customer.

The pre-prepared interview templates were adjusted to fit each interviewee's field of expertise prior to the meeting. All interviewees utilized prepared templates and practiced open-ended questions, hence allowing for elaborated answers, follow up-questions specific for the conversation and ultimately a comparison between the interviewees and their answers without guidance (Bryman & Bell, 2014).

On beforehand, it was decided to keep conducting interviews until data saturation occurred, i.e. the level of newness in the data gathered got low, hence making further interviews a waste of time (Bryman & Bell, 2014). As a result, seven unique interview-occasions were held with representatives from recycling companies performing garbage collecting activities. Additional external interviews totaled to five with two from distribution companies and one each from the other previously mentioned stakeholders. Critique and questionings may be raised against the fact that only one interview was conducted with each of the representatives for politics, universities and the energy sector. Nevertheless, the researchers still interpret the data as reliable since the level of novel insights raised from these interviews where low and to a large extent the same as those provided by the customer category or found in previous literature.

To lower the barrier against participation and simultaneously allow the interviewee to answer questions in a comfortable environment (Bryman & Bell, 2014), the options of a personal meeting or telephone interview was given in the interview-inquiries. Interviews in stage 1 and 3 where all held in person while the distribution was seven (7) to four (4) in favor of personal meetings over telephone calls for interviews in stage 2. Few short follow up-sessions were held to clarify certain uncertainties and were conducted via telephone. All interviews were conducted in Swedish which also was the native language of all respondents. Prior to each meeting a short introduction of the study's overall question of formulation and the interviewers' expectations on the interview was provided. This was partly perceived as an efficient way to balance between retrieving honest answers and avoid bewilderment from the interviewee, but also ensured that the approached respondent possessed the information asked for, hence ensuring the validity of the data.

Both researchers were present during the interviews and actively participated by asking questions, hence decreasing the otherwise significant risk of subjective interpretation and interview focus from a single interviewer (Bryman & Bell, 2014). Most interviews were recorded (after granted permission from the interviewee) and only minor notes taken during the sessions to instead turn all the focus to the conversations. To avoid potential discouragement of revealing sensitive or challenging information, the researchers applied the advices from Easterby-Smith et al. (2012) and made clear to the interviewee prior to start that the all respondents would be treated as anonymous. Additionally, it was explained that the recordings were only for the researchers' own memory and allowing the talk to flow without heavy note-taking, but that the recording device at any time could be paused if preferred. Notably is that the interviews weren't transcribed afterwards which otherwise is a common practice in qualitative research. The benefits associated with transcriptions including, citation extraction, possibilities for indexation of recurring terms or arguments and possible reuse of the raw data (Bryman & Bell, 2014) was to a large extent considered unworthy the efforts or irrelevant.

Instead, the interviews and emerged ideas were summoned immediately afterwards and eventually carefully re-heard by both researchers individually at the time of result-synthesizing and analysis for retrieving characteristic quotations. At this point, a perception over certain key themes started to appear which thereafter became the structure of the analysis when addressing the research questions.

3.3.3.1 Internal workshop

A workshop with seven attendees from various departments internally at Volvo was held where the gathering's purpose was three-folded. Firstly, it created an opportunity to share insights and knowledge that had been retrieved from outside the company's wall. Consequently, an opportunity was created where the assembled information could be either confirmed or questioned by the attendee's own interpretations.

Secondly, the workshop purposed to confirm the researchers' interpretation of the existing business model and complement gaps regarding differences between incumbent manufacturers. Thirdly and perhaps most importantly, the workshop created a forum where discussions freely could be carried out. First and foremost, discussions regarded what implications emobility would bring for Volvo's truck business and what strategic questions that were perceived most crucial arose. Additionally, a rewarding discussion emerged organically between the participants where knowledge was shared and transferred from those belonging to the bus department of Volvo to the ones from the Volvo Trucks.

Practically, the workshop kicked off from the business model canvas presented by Osterwalder and Pigneur (2010) where each of the nine elements was gone through in the order suggested by the originators. The rationale for applying the canvas instead of the study's main framework was due to the canvas being judged by the thesis writers as more practically applicable with for example pre-formulated questions for guidance. Additionally, the anticipated reconnaissance among the participants was another factor leading to the decision. To reduce the risk of misinterpretations and reach a higher level of efficiency, a PM was sent out three days prior to the workshop-day. The information contained both a selection of earlier findings and what framework the workshop should be based on. During the activity, discussions and statements was logged on post-it notes and put on a whiteboard for everyone to see and comment if anything had been interpreted wrong from the talks. Consequently, the risk of misinterpretations was reduced and instead increased the reliability of the session.

3.4 Trustworthiness of the study

Four criteria together constitute the trustworthiness of qualitative researches: credibility, transferability, dependability and confirmability (Bryman & Bell, 2014). Credibility are to equalize with internal validity and the study's conformation with the reality. Transferability parallel to external validity and contribute a lot to the study's generalizability to the large context. Dependability refer to reliability of the qualitative research while confirmability at last refer to the objectivity of the study and the researchers' personal values influencing the process or results (ibid.). To reach a sufficient level for dependability and confirmability, the report's methodology chapter has attempted to transparently explain and motivate in detail how the study has been conducted and research questions answered. Not least is Figure 6 perceived to increase the trustworthiness of the study by fully transparently explain what activities and stages the research has gone through to reach its result.

To enhance the objectivity, the thesis writers has worked closely together with long and thorough discussions and iteratively exchanged perceptions or findings with supervisors both at Chalmers and Volvo. Together with continuous literature reviewing over both the truck industry and the theoretical components of the conceptual framework, the retrieved data has been triangulated whereas the level of subjectivity is considered to have been decreased. Additionally, triangulation is an acknowledged method for supporting studies' credibility by cross-checking collected data (Bryman & Bell, 2014) and it is of the researchers' apprehension that this undertaken validation technique has kept misunderstandings or misinterpretations to a minimum throughout the study. Furthermore, the research adopted a process from aligned with good practice which is another established act for enhancing the credibility.

Qualitative studies generally struggle with contextual uniqueness which might infringe the level of transferability where findings might be restricted to the specific world studied (Bryman & Bell, 2014). Consequently, transferability and generalizability haven't been of highest priority for this study which instead has targeted a rich and broad analysis. However, as Bryman and Bell (2014) emphasize from previous works of Denzin and Lincoln (1994), thick descriptions may be just as fine since it target to provide a database available for others to make judgements regarding the possible transferability to other contexts. Consequently, the purpose and research questions have been formulated wide and explorative, obviously targeting to add another case study to the body of knowledge within the scientific field. The writers do however argue that the empirical findings are foremost applicable to the Swedish refuse truck industry but may also possess some trends or process steps applicable to other industries or segments, not least for heavy vehicles.

4 Empirical findings

In this chapter, findings form conducted interviews and TCO calculations are presented in the following sequence: How the business model is today, Customer insights, External stakeholder insights and finally The economic characteristics of emobility. Today's business model follows the structure of the undertaken business model framework, i.e. divided into: value proposition, value creation and value capture. Customer insights mainly focus on refuse truck operators. Findings from external stakeholders include aspects from electric companies, politics and university. The economic characteristics presents our own TCO modelling. This chapter however starts with a desktop research regarding emobility and what changes or strategic issues that arise from the technology.

4.1 Emobility – what differs?

Beyond being emission free, an electric driveline has several technical benefits but also drawbacks compared to the diesel counterpart. One of the largest benefits with an electric powertrain is the efficiency. For a diesel truck, the normal efficiency in transforming the energy in the fuel to kinetic energy is about 35-45% (Giannelli et al., 2005) while the efficiency is over 85% for an electric engine (Gustafsson & Johansson, 2015). Consequently, the entire electric driveline obviously becomes more effective. The downsides with fully electric cars or trucks are however several. One is the limited driving range that an electric battery pack brings. Additionally, the time it takes to recharge the battery further restrict the flexibility and usability. However, it is possible to put in very large battery packs and thereby achieve 8+ hours without recharging. But this comes with the downside of making the truck very expensive as the costs of a battery pack in today's electric passenger cars already make up to 48% of total costs (Curry, 2017). With trucks needing even larger batteries, a scale up in battery capacity can easily exceed those 48%.

Large battery pack also affect the loading capacity which is a very important factor, especially for city distribution where allowed weight and axel pressure often are limited. For example, in Sweden the loading limit for trucks are 63 tons[1], but within cities it is common with road classification BK3[2] meaning that trucks with an axel spacing of 5,3 meters maximally can weigh 16,5 tons on a BK3 road. Shorter trucks will have even lower weight allowances (Vägverket, 2002). The recently announced Tesla Semi's largest battery configuration with a range of 805 km (500 miles) is rumored to need a 1000-1200kWh battery weighing around 5100 kg (Bower, 2017; Turpen, 2018). This will naturally limit the load the truck is allowed to haul, especially on already limited roads.

When it comes to charging the batteries, there are several solutions with their own advantages and disadvantages. Some of the techniques that both historically and presently has been considered are night charging, fast charging stations, battery swap and through overhead lines

[1] For trucks with a length over 20,2 meters between the front and rear axle (Transportstyrelsen, 2018a).
[2] BK3 stand for "Bärighetsklass 3" and is a classification of the road carrying capacity allowed on a specific road (Transportstyrelsen, 2018b)

or inductive charging buried in the road (i.e. so called electric road systems, ERS (Tongur & Engwall, 2014)). Inductive roads and overhead lines are a very expensive infrastructure. Additionally, inductive charging also have large losses in the transfer of electricity with an efficiency of about 80-85% and chargers only able to supply a maximum of 5 kW (Wu, Gilchrist, Sealy, Israelsen, & Muhs, 2011). Consequently, ERS are unfeasible for at least the first implementations of electric trucks whereas the logical alternatives are restricted to battery swapping, night charging and/or fast charging.

Charging by night more or less only require a large three phase outlet[3] to connect the truck to. If not already installed, the only investment needed will be the wiring work which reduces the investment costs, hence making night charging a cost-effective alternative. However, the consequence will be a charging time of 8-12 hours for fully charging a battery with 200-250 kWh capacity. Fast charging stations on the other hand often complete a full charge in 1-2 hours. This is achieved by having a separate AC to DC converter much larger and heavier than the one that can be placed inside a car or truck. These fast charging station are unfortunately expensive to buy and install where estimated costs for passenger car stations lands around 2 million SEK/charger with a capacity of 350 kW (Wissenbach, Busvine, & Steitz, 2017). Another technique that has been investigated is battery swap, where discharged batteries are swapped to a fully charged one, either at a station or by road assistance. This model has been tested by Tesla for their model S, but the project was canceled due to lack of interest (Korosec, 2015). It is also an expensive and capital accumulating solution.

[3] Three phase electric power consists of three alternating currents with the same amplitude but with a 120° offset. It's frequently used in residential, industrial and commercial spaces (Wikipedia contributors, 2018)

4.2 RQ1: How is generally the current business model for trucks designed today?

To address above research question, literature reading was complemented with interviews, talks and a workshop with seven individuals at Volvo from various parts of the corporate group. All findings in this subchapter originates from interviews or the workshop at Volvo if nothing else declared and is structured as the framework-conceptualization over business models provided by Clauss (2017).

4.2.1 Value proposition

Trucks are a global product with presence all around the world. The industry inhabits many actors but is dominated by fewer large corporate groups inhabiting manufacturers who compete against each other internationally (Tongur & Engwall, 2014). The truck market can be segmented in numerous ways beyond the traditional market segmentation of premium, budget and low-cost markets. As an example, Volvo aim to compete on markets segmented in two ways – by industry or by customer type. Particularly the customer segmentation was explained to be applied which stretch from chassis customized for city distribution all the way up to demanding long haul and heavy construction vehicles. In terms of such segmentation, refuse trucks where addressed to the category of smallest vehicles – city distribution trucks. Geographically, the company competes on a global arena, though with Europe and North America as key markets seen from a net sales perspective (Volvo Group, 2017).

The main value provided and indirectly sold from the manufacturers of trucks is flexibility and high capacity to relatively low costs (Tongur & Engwall, 2014). According to I1, selling points from manufacturers to customers has traditionally been focusing on features of the vehicle such as engine capacity etc. Also power performance, safety, durability, and reliability has traditionally been common important aspects for convincing the customer (Tongur & Engwall, 2014). Additionally, value propositions in terms of branding communicated to customers and society was during interviews found to differ between actors where e.g. Volvo has focused on being associated with safety, environment and quality.

However, interviews reveal that the range of value propositions provided by truck manufacturers to the market in general is extensive. Beyond the physical vehicle as core product, manufacturers' offerings stretch into the field of services where efforts for developing services to sell as "add-ons" are made. Service contracts with various degree of coverage regarding maintenance has for a long time been a major part of the aftermarket in the industry. For the customer, the value of such contracts lies according to I3 in the enabling of an even, predictable cash flow and operating cost for the vehicle instead of high occasional invoices from service and maintenance. Other offerings perceived by I3 that Volvo compete with include an extensive range of chassis to choose from and traditionally strong own development of well-performing engines.

Beyond the aftermarket, additional services have been included into the portfolio of offerings. As I15 explained, financial services which offer various financing solutions have for a long

time been a common practice in the business. Additionally, digital services such as fleet management which gather data about the vehicle's performance and usage before compiled and sent to the fleet owner is according to I15 growing as an increasingly important dimension for winning the customer who continuously search to optimize the output of his vehicles. The expansion into service offerings furthermore pave the way for providing truck driving training program, fuel control system and systems for logistics to compete with (Tongur & Engwall, 2014).

The channels through which value propositions are communicated and delivered to customers are mainly derived to authorized distributors or service centers. In Volvo's existing business model, such channels include both external repair shops and the own dealership network which function as the company's interface to customers. In terms of sales process, the logic of premium truck manufacturers, i.e. Volvo, Scania, Mercedes etc., has typically been to let customers order products from a catalogue of chassis, bodies and specifications. Spare parts and maintenance services has thereafter been possible to source from both the manufacturer directly or authorized distributors (Tongur & Engwall, 2014).

An increased degree of digitalization of the industry and offerings has however brought the manufacturers closer to their customers e.g. due to interaction through fleet management reports. Compared to the process for selling the physical vehicle, service businesses in general demand a more dialogical relationship between manufacturer and customer (Tongur & Engwall, 2014). Taking it one step further, I16a highlighted the necessity to understand that *"we cannot only focus on selling our vehicles but must consider the fundamental need of the customer"*, hence referring to increased co-creation of value between customer and manufacturer. As further emphasized by I16b the importance of educating and influencing the customer's costumer is growing whereas the importance of interaction through online channels such as social media and website is growing.

4.2.2 Value creation

Truck manufacturers' value adding has historically been (and still is) related to technical components such as the internal combustion engine, transmission, chassis and cabs (Tongur & Engwall, 2014). Naturally, the diesel engine has become the competitive factor of most actors (ibid.) whereas activities, partners and resources are formed for such value creation. Conducted interviews confirmed that notion achieved from literature and explained engineering, design, manufacturing and R&D as the most important activities to carry out. The argument was found two-folded as I16c explained that such activities both improve existing technology and drive innovation.

Service and support are other significant activities to fulfill the delivery of pursued value propositions to the customer. The perceived importance was illustrated by I15:

"Buying maintenance on a service basis on the aftermarket has not only become a commodity for the business, but services have also expanded into the digital area. Being more and more

of a differentiator, the development of new digital services is one critical activity for us manufacturers."

The aftermarket for trucks is a complex job which puts high demands on availability for spare parts and capacity at repair shops to reduce downtime. To ensure the delivery and creation of this value, vehicle manufacturers employ both service centers and authorized distributors. Service centers are often arranged in the manufacturer's own management while authorized distributors are external actors contracted through partnerships. While Volvo's service center, Volvo Truck Center, in Sweden contain 17 facilities, the number of authorized dealers and repair shops amount to 94 (Volvo Group, 2018), hence implying the importance of well-functioning partnerships to offer national coverage.

With fuel economy as a major cost driver for vehicle owners, manufacturers may create tremendous value for its customers with fuel-efficient engines. The key role of the powertrain has therefore historically led to in-house development and control by the manufacturer, while other components are being sourced from suppliers and assembled at the manufacturer's plant. In fact, the sourcing activity is extensive with Volvo having up to 70% of trucks' components acquired from suppliers. However, a difference between manufacturers regarding the engine does exist where some have taken the strategic choice to live in symbiosis with an external powertrain manufacturer specialized in explicitly developing and sell engines to several truck manufacturers.

Also, market demand and consequently, the role for value creation are found to vary geographically. In the United States, manufacturers' role for creating value comes from assembling trucks for their customers who have tailored their own trucks by ordering components separately, while European customers traditionally expect to order a complete truck from one company (Tongur & Engwall, 2014). Though different, these separate models share a common need of integrated partnerships with suppliers. During interviews, joint collaborations with suppliers for improving and optimizing the technology where found to be a frequent element of manufacturers' activities, not least to ensure technical quality.

The most common setup in the truck industry is that the manufacturer such as Volvo and Scania build the chassis including driveline and cab, while a third-party construct and attach a body to it. However, to fulfill the proposition of a customer-friendly mode of operation, collaborations with bodybuilders are established to offer a complete truck to customers through one interface. Consequently, the buyer only needs to approach one salesman and the manufacturer handles all the configuration. For Volvo, such a setup result in partnerships with large globally present bodybuilders[4] and enables configuration of standard vehicles for quick delivery. During the aftermarket, the Volvo dealer handles all maintenance, service and guarantee errands to ease the ownership for the customer. However, as explained by I3, the offering of standardized vehicles does not renounce the flexibility, but customer specific configurations and adjustments is yet made to a large extent.

[4] Bodybuilders include e.g. JOAB, Zetterbergs, Sörling, SKAB, PLS, Zepro (Volvo Group, 2018)

Partnerships with technology developers is another important factor in manufacturers' business models, not least as the degree of digital services increases. Such collaborators may be both companies or institutions who drives technological innovation and identifies new fields of application. Not seldom are such companies either acquired or contracted as suppliers while knowledge institutions remain a source of ideas and early research support. An established partnership with research institutions and universities also function as a provider of competence to employ into manufacturers' or partners' organizations. In terms of resources, such supply of competence and capabilities were found considered as crucial to Volvo to remain in the forefront of its areas of expertise.

Resources in terms of physical facilities, both for production and aftermarket services, are naturally necessary to possess in order to create the value propositions. The extensive dealer-network with both contracted and Volvo managed dealers is according to I3 one of the most important resources possessed by the company for creating full value to customers. Ownership of technology, e.g. through intellectual property, is also considered a necessary resource to remain competitive. Protection of core competence, for Volvo the industry leading diesel engine, is like in most industries a mean to either monetize on R&D through licensing or protect technological competitive advantage.

To be able to provide financing options, insurances and leasing opportunities to customers, most automotive manufacturers manage their own finance operations similar to a bank. This function is important to manufacturers where e.g. the subsidy Volvo Financial Services financed 25% of the entire Volvo Group's sold products in 2017 (Volvo Group, 2017).

4.2.3 Value capture

Value capture includes both the cost structure and monetary revenue stream of the company's processes and offerings. As a consequence of manufacturer's focus on developing individual powertrains to compete with, a considerable portion of today's costs is tied to the engine and critical powertrain components such as transmission and gears. Not at least is R&D a large cost driver, especially among premium manufacturers. As remarked by Tongur and Engwall (2014), actors like Volvo and Scania indicate that half of their R&D budget is allocated to developing the diesel-based powertrain technology.

Though the manufacturing of powertrains and belonging components is highly sophisticated with narrow tolerances, the production is made in large scale and to a large extent automatized, hence becoming less labor intensive and reduced as a cost driver. A large proportion of the manufacturing is further allocated to suppliers and subcontractors to be delivered and assembled at the manufacturers plant. Costs are furthermore derived to the network of repair shops which is a labor and resource intensive (yet necessary) operation for most vehicle manufacturers.

The complexity of the powertrain creates an opportunity for truck manufacturers to play a key role and obtain revenue from the aftermarket as well. The providence of spare parts and

technicians geographically widespread through a network or repair shops generate good and recurring profits even after sale (Tongur & Engwall, 2014). For the entire corporate group of Volvo, sales of services including insurances, renting, spare part sustentation, maintenance contracts, assistance services and IT-services accounted for 21% of net sales (Volvo Group, 2017).

However, sales of vehicles are still the most important source of revenue for manufacturers, though the increased importance of services. For Volvo Group, sales of both new and second-hand vehicles, machines, bodies and specially manufactured vehicles accounted for 75% of net sales (Volvo Group, 2017). With products sold for millions of SEK, made to last for a decade of usage, revenue streams risk to become highly fluctuating and irregular. Subsidies or corporate functions practicing financial services and enable leasing solutions flatten the revenue streams. Additionally, the financing business contribute to balance rises and settings in the order-book for new vehicles.

4.3 Customer insights on emobility

Findings from the customer category were retrieved through interviews with company-representatives well possessed of knowledge in vehicles and their company's fleet strategy. The interviewee's organizations varied and spanned from recycling companies with refuse collection to large forwarding agencies with both city and long-haul distribution.

4.3.1 Perceived value propositions of emobility

Table 6 in the end of this subchapter declare main value propositions on emobility as emphasized by interviewees in the customer segment. When asked about perceived value propositions associated with emobility and electric vehicles, all interviewees independently expressed emission neutral operations as the major benefit. The possibility to perform transportation activities without NO_x and CO_2-emissions were found to possess a profiling-value. Especially representatives of recycling companies emphasized the desire of emission free transports as an obvious puzzle piece for their image as sustainability-promoting actors. Some interviewees broadened the scope and combined electric vehicles with other green technologies for becoming entirely climate neutral:

"Additionally, we have started to look at solar cells to our facilities in Jönköping and Borås where we also have trucks that come and go in the same place every day and night. […] If you also can connect it [the charging of electric trucks] with the solar cells, then it's a question of total emission impact of course." (I4)

"Our goal is to be climate neutral, just like everyone else in Sweden, and we see it as a survival issue to be climate neutral and eliminate the negative effects on the climate from transport. […] But that also applies to renewable electricity, whereas the connection to the energy sector gets tightened." (I11)

Another value proposition addressed by customers was the noise reduction where silent drive trains were expected to create a more enjoyable working environment for the operators. Simultaneously, all interviewees declared the complexity of quantifying or monetize on such propositions, whereas the aspect was rather mentioned as a positive "soft" feature. Beyond the reasoning about working environment, the notion of silent and emission free vehicles enabling new ways to operate was given by half of the respondents. However, the arisen opportunities where simultaneously explained as limited by other factors. As elaborated by I5 and I9 separately:

"If we had a quiet truck, we could actually pick up what we need to pick up at any time of the day. […] We could drive and reach the pick-up objects easier without traffic, which creates a better working environment for our employees." (I5)

"We have three electric hybrid trucks which the drivers experience, and I've also taken a test ride, as wonderful. Quiet, they can talk to each other and get rid of the engine noise. So the working environment is great. But! What's disturbing is the mechanical sound from what's

thrown into trash cans respectively as we walk with the barrels over cobblestone streets. […] There are barrels that are made silent and you may dress the wheels but then you have to replace all the current barrels. That would imply capital destruction." (I9)

Interviewees where further asked what propositions would determine which vehicle brand to invest in once convinced about electric vehicles. Here, a large majority (8 out of 11) emphasized dependability as the most essential factor of their operations. Consequently, a manufacturer capable to either guarantee or provide most uptime was the one most attractive when faced with a purchasing decision according to interviewees. In relation to above proposition, some interviewees (3 out of 11) highlighted the necessity of close relationship with the salesforce from the vehicle manufacturer – both for bringing trustworthiness to promises of dependability but also for being able to retrieve custom made solutions.

Table 6: Value propositions coming into existence with emobility as emphasized by interviewees from the customer category.

Interviewee ID	***Emphasized value proposition(s)***
I4	Reduced CO_2-emissions Self-supporting on energy through electric vehicles and solar panels
I5	Improved working environment Emission-free operation Noise reduction
I6a+b	Environment and emission free operation Noise and working environment
I7	Noise reduction Climate neutral company profile
I8a+b	Less maintenance and a simpler powertrain (mechanically) Reduced need for monitoring oil level Working environment Emission-free operation Climate neutral company profile
I9	Working environment Emission-free operation
I10	Climate neutral company profile Wash off stamp as an "environmental bad guy" Noise reduction
I11	Climate neutral company profile Customer relation New offering to the market

4.3.2 A new cash flow perceived as a financial barrier?

When talking to customers, they are generally interested and possess a favorable view of electric trucks and its technology. The fact that an electric truck potentially will have a higher purchasing price than its diesel counterpart due to the expensive batteries wasn't seen as an issue or problem by any interviewee as long as the TCO wouldn't be higher as the citations declare:

"*It is the total cost of operation during the trucks lifecycle that matters*" (I6).

"*In the end, it is the total cost that matters*" (I8b).

"*If we are to be really honest, it's absolutely irrelevant what it costs in purchasing because it's the TCO over time that matters.*" (I5).

"*Even if we own the trucks, we finance them through financial leasing. I would not see a barrier if the trucks were more expensive, if the total cost is one to one.*" (I7).

Similar statements were made by all customers during the interviews. Following up on the question and asking if there would be any issues with a larger down payment due to a larger loan, the interviewees diminished the potential impact:

"I don't anticipate that a larger down payment would be a problem, it would be quite negligible." (I7).

"*In reality it will only be a difference when calculating the costs for the truck, the figure for interests and deprecation will rise, but hopefully some other parameters will decrease as much or more. So I don't see it as a problem.*" (I4).

Conducted interviews reveal a common notion among haulage firms and refuse operators. That it would be difficult to charge their customers more if they were driving fully electric trucks, instead of today's diesel or gas trucks. Simultaneously, some hinted that they maybe could see an opportunity that some of their customers could pay a bit more for electric transports:

"*If we could go to the municipality and say that we now leave diesel and invest in electric engines, batteries and solar energy and ask them if they could pay 100 000 SEK more? That wouldn't work, because they would violate the Public Procurement Act in Sweden.*" (I4)

"I think that our customers from the industry can probably buy it as an argument to leave fossil fuel. Many of our customers, especially large customers are carefully examining their environmental impact in several ways and I think they might be interested." (I7)

During several interviews, it was revealed that it was possible to earn bonus points or receive deductions on a public procurement if leaving an environmentally friendly option. Consequently, as small optimism was declared over the potential of being paid more for an electric truck.

"*From a municipality you can often get additional compensation for environmentally friendly solutions, but it has to be initiated by the municipality during the public procurement*" (I4).

Other issues that were anticipated are allocation of the first few electric trucks when only some of the clients are interested in paying more for electric trucks. As summed up well by I11 during the interview:

"*It will be a difficulty, if we buy 3 electric trucks and including them in our network, then they will not be dedicated to a specific customer, they need to be included in our fleet of trucks. This has the implication that the electric truck will not always drive that customer's goods. The challenge will be to get customers to pay even when their goods will be delivered by a diesel Euro 6 truck driving on sustainable biofuel and the customer expect an electric truck since they paid for it."* (I11)

Interviewees further witnessed about their previous experience with customers telling them one thing and later having other priorities. This creates skepticism towards their customers and what they are actually willing to pay extra for:

"*Unfortunately, from what I've seen for several years, in all positions and roles all customers praise environmental engagement, good values and certified companies. But when it comes to the reality and what it costs, it usually fails. Then they are not willing to pay what it actually costs. Instead it is something that should be included in some way anyway. But that's not possible since someone needs to pay the difference between what is costs compared to traditional production. I would like to say that there are contradictory standards at most companies and municipals in Sweden. One wants to get the best environmental performance, but are seldom ready to pay for it, they might accept to pay a bit more.*" (I7)

"*Within a purchase period, the customer can initially push the environmental aspect, but during the final sale negotiation and you have added 1% to the total cost as a environmental cost it is very easy for the customer to say "we can eliminate that proposal" in the end."* (I10)

4.3.3 Customer requirements and perceived barriers for adopting the technology

To create an understanding of customer's need and preferences for the emobility-technology, questions were asked about what technical requirements the interviewees had to fit and run their daily operations. Interviews revealed that companies, particularly operating within the refuse truck industry, want a truck that is able to drive a full work shift reliably. A full day were found to equal 8-10 hours of operation which is well aligned with the treated vehicle data used for TCO calculations. Technically, concerns were raised regarding the ageing of batteries and their endurance after several years of usage where it was explained that a decrease in performance was unacceptable. Half of the interviewees also stretched their concerns to the environment's effect on the vehicle's performance, particularly when operating in the winter and brought up previous negative experiences with new technologies.

"*A truck need to have a 10-hour driving range, we need some margin*" (I9)

"Let's compare with gas trucks. Novel technology but maintenance costs were so high that the economy remained absent. And they also had a very expensive purchase, and were told to have lower operating cost, i.e. the gas was a cheaper fuel than diesel. But it was such a huge repair cost and uncertainties if you even would get the trucks out in the morning. So eventually, the technology was shut off, and not so many gas trucks operate anymore today." (I6b)

After been explained the possibility of technical limitations, especially related to battery capacity and driving range of the trucks, all interviewees announced their operations' practical capability and willingness to optimize their route planning to favor electric trucks. However, the demand for a full day's battery capacity without charging remained among all interviewees except two (I5 and I6a) who yielded that they could allow a refuse truck that needed to be charged during the 45 minutes long lunch break. Though under the circumstances that there were charging stations with guaranteed capacity placed in such a way that it is possible to plan them into the daily routes. For the other interviewees, being dependent on charging during the day where regarded as a too large restraint to the flexibility of the system.

"Generally speaking, I would say that it will be quite difficult for us. It would be too much energy loss to go to a specific place to charge during the day." (I4)

"Actually, it doesn't matter to us. The most important thing is what direction in which the vehicle manufacturer chooses to go. Should there be maintenance charging during the day, then we do as in Gothenburg with buses that charge at the stops during breaks. Or we'll charge overnight, that's fine as well." (I5)

"*Our days are quite similar […] The drivers drive their routes and it is possible to decide and plan them in advance*." […] "*If we have charging stations at certain places in the city and we can plan so that the break can be taken after 4,5 hours over there and we charge for 45 minutes and then continue. We don't see that as a problem.*" (I6a).

One requirement that emerged during the interview was the load factor which dictates the maximum payload allowed for a truck. Several interviewees urged the impact weight limits have in the cities were roads often are limited to lower weight classifications and garbage can be heavy from glass, metal, newspaper etc. As illustrated in the citations below, the awareness of the potentially large battery packs to ensure sufficient range and the problems these may bring due increased weight where thereby a barrier to adoption perceived necessary to address:

"*We need to be able to load at least 6 tons, but we know that it is difficult*" (I9)

"*The technology is not there yet that it is able to haul the loads that we require*." (I6b)

"*We have limits for the axle load allowed on the roads and a refuse truck is heavy with its refuse compactor that is needed. The payload becomes critical quite quickly.*" (I7)

4.3.4 Customers on services and aftermarket arrangement

When asked about value propositions differentiating vehicle manufacturers from each other, a well-functioning aftermarket providing vehicle service and maintenance was perceived as the most important aspect among the interviewees to achieve from their vehicle supplier. Aligned with such a proposition, I8a returned to the technological benefits by explaining that "*Mechanically and from maintenance point of view, it would be a dream with electric trucks*", hence expressing all heard customer's common search for dependable vehicles and less time

spent in the repair shop for service. As illustrated in the citation below, I4 stretched the aftermarket's influence and emphasized that the access to near-located repair shops in many cases had determined who to buy the vehicle from and placed technical specifications as a secondary aspect.

"We bought Volvo trucks to operate in that area which I consider to be a faulty decision. Instead, we should have bought Scania trucks since Scania has a workshop in that area which Volvo doesn't, whereas the aftermarket would function more smoothly." (I4)

"The entire system is built around the fact that it is the chassis supplier who supply spare parts through a network of workshops. Because that's what's difficult, knowledge and spare parts supply." (I5)

A vast majority of interviewees from the customer category identified the aftermarket as a very natural and integrated part of the vehicle purchase. Additionally, it was revealed that all of the interviewee's companies had chosen the path of buying service contracts along with their vehicle purchase. The rationales were found to stretch from establishing a predictable cash flow to ensuring the possibility of compensation for downtime from the manufacturer. However, some interviewees still announced flexibility in their maintenance arrangement by expressing occasional simpler repairs being made at repair shops outside the manufacturer's network.

In terms of other kinds of services, several respondents reported that their vehicles were connected to a fleet management service provided by the vehicle manufacturer. The rationale for subscribing to such services was mostly to keep track of the vehicles performance, well-being and predict potential breakdowns in advance. The connectivity service was also found to simplify the daily operation for the operators:

"Yes, we have such services, partly to connect the tachograph to the tachograph monitoring program to eliminate the need to print out with scanning cards and stuff. Instead, the system reads the tachograph and driver card automatically." (I4)

When asked about current financing solutions for today's trucks, the interviewees provided a shattered picture with several different setups and service exploitations. While some regarded to own the truck themselves (and potentially finance it through a bank loan) were most beneficial, other referred to a leasing arrangement as their most rational choice. The leasing arrangements were found to vary and included both operating and financial leasing[5]. Furthermore, the differences in setup were found not to be limited between firms but also occurred within fleets.

[5] In a finance lease agreement, the lessee is responsible for the vehicle during the leasing period and pay for maintenance, insurance etc. It also entails that the lessee agrees to buy the vehicle for its residual value after the leasing period has expired. In an operating lease agreement, the leaser remain as the owner with full responsibility over the vehicle even after contract expiration. In both cases, the payment is being made continuously, e.g. monthly or by mileage. (E-conomic, 2018)

4.4 External stakeholder insights on emobility

This subchapter shares insights and findings achieved from stakeholders strongly linked to emobility at this present stage. The stakeholders are exclusively existing downstream the value chain whereas upstream suppliers including battery pack producers are excluded. Instead, interviewed stakeholder-representatives belonged to the energy sector, politics and university community.

4.4.1 Electricity companies' interests

The input on emobility from the energy industry were retrieved from an interviewee (I13) representing the energy sector's collective interest organization, hence possessing an aggregated overview of the energy companies' interests and roles in emobility. When asked about the general familiarity of emobility within the energy industry, I13 explained that the electrification of the transport sector already has passed the position as being the future and is rather considered a feature of the present time. Simultaneously, the industry-actors' actions is explained as fairly passive:

"The energy industry is very conservative, and I would say they aren't doing anything, but rather hang on a little. And if they hadn't been nagged on, they would probably prefer to do nothing." (I13)

The perceived potential value to obtain from the emerging development is naturally mainly focused on economic benefits. As I13 explained:

"In the end, it's about economy, of course. One sees that there is money to earn here. Not today I would say. It depends a lot on business models, but it's hard to make money on charging infrastructure today […]. But that's how they think [the electric companies], they think very long-term. All these companies see the potential of the electrification of the transport sector and know they won't make money in the first few years but know that this development will take place." (I13)

In regard to above statement and perceived low profitability, the interviewee highlighted the necessity to separate public charging infrastructure from non-public where the last-mentioned is easier to achieve profitability from than the public counterpart today. The reason is deduced to quantity where non-public chargers usually is sold in larger numbers to companies investing in entire electric vehicle-fleets. Additionally, the importance of winning the agreement of the charger's operation and maintenance has emerged to generate continuous revenue from the chargers. Consequently, actions for securing such contracts has been integrated into the energy companies' business models. Procurements for full responsibility are nowadays made where the energy companies utilize electricity price discounts to persuade the fleet owner, exactly as gas companies (or even specific stations) historically have offered lower gasoline and/or diesel prices if the vehicle owner buys all the fuel from the same supplier (I13).

The emergence of electric vehicles has segmented the web of actors in the energy industry and made the stakeholder situation trilateral where the two traditional actors - the large electric grid-owners and electricity companies - has become accompanied with charging station operators. Furthermore, I13 explained that the actors possess different interests for emobility which also split up the revenue streams. The national grid owners are explained to constrain their involvement to the geographical planning of suitable locations for charging infrastructure and perform the ground work, i.e. put the cables in place. Ground work is namely one of the major cost drivers, hence dealing with sums large enough to catch the grid owners' interest.

The grid owners' disinterest in installing and selling electricity through chargers creates a space which electricity companies has claimed. However, the interest for running operation and maintenance for the physical chargers is low according to the interviewee whereas a final space opens up which historically has been filled by start-ups trying to capitalize as charging operators. The success rate for the segment in Sweden is explained as variating due to the low utilization and demand:

"They [charging operators] are very few if you look at Sweden and it is because you cannot be a small player and enter that market because there isn't much money to earn. Yet." (I13)

When asked about current movements within the energy industry I13 mainly witnessed about closer collaboration between the automotive and energy industry:

"The car industry has traditionally been very conservative, but now they are beginning to understand that the electrification applies. Consequently, new collaborations have been initiated with these companies [electricity companies/charging operators]. Looking at Sweden today there are charging operators who collaborate with car importers such as BMW, Volkswagen, etc."

For the electricity companies involved in emobility projects, today's value of investing in charging infrastructure is mainly associated with PR. The image of being innovative and in the forefront of green technologies locally has in most cases been enough to engage with such efforts. Once again, I13 emphasized the importance of the non-public market.

"I think, that if you want to build a business as an energy company, you should now invest in the non-public sector, i.e. selling charging stations and electricity to electric vehicles in their homes or companies and their parking spaces."

Regarding charging infrastructure outside local regions, the energy companies' role is found significantly lower. Instead, car manufacturers are reported to carry out the build-up infrastructure themselves through collaborations. The founding of IONITY[6] as a joint venture between Daimler AG, Volkswagen Group, BMW Group and Ford is such an example.

[6] As a joint venture, the consortium target to build and operate 400 fast chargers spread across Europe by 2020. With a charging capacity of 350 kW, the target it to enable long-distance travels with electric vehicle (IONITY, 2018).

Additionally, just as all interviewees from the customer category, the energy industry points out political policies and incentives as the most significant trigger for boosting the electric development. And the electrification is considered as certain, despite political policies of technology neutrality, where subsidies for electric cars and charging stations has been issued. Altogether, the interviewee perceive politics in Sweden to be compliant with its large industry actors which strengthen the prospects for an electrification.

4.4.2 The aspect from politics

When bringing in perspectives from the political arena, I14 asserted that emobility were well known in the political environment and "*that electric vehicle has been bubbling for some time now and we all await the plug to let go"*. To accelerate the development and learn more about the technology, its capabilities, opportunities and limitations, Västra Götalandsregionen (VGR) is been involved in "ElectriCity" - a combined demonstration and testing project for electrically driven buses in city traffic which involves various actors in the Gothenburg area (ElectriCity, 2018).

I14 agrees with the other interviewees and their perception that governments in general and municipals in particular holds a key role in the realization of electric trucks, e.g. by establishing requirements in the procurements which favors electrification. In Gothenburg, the board of public transportation figurate as a commissioning body for Västtrafik who run the public transportation in the region through subcontractors. The means possessed by politicians to steer the development becomes indirect and limited to expressed wishes to Västtrafik which in turn spills down on potential subcontractors' offerings brought to the negotiation table.

However, I14 foremost identify the role of guiding transportation companies by bringing stability and long-sightedness to the context as municipals' and policymakers' most important. In such a role, the most difficult challenges include to balance the assuring of technology neutrality and simultaneously fostering innovation and speed up diffusion. As I14 explain:

> "*The most challenging for us I must say is to be a neutral party. We cannot favor any company in front of another, i.e. we cannot go on and only benefit Volvo, but we must also keep open to Scania and other vehicle manufacturers to participate on equal terms. And that can be a difficult balance sometimes if you want to drive innovation together*."

When asked about infrastructure and charging, I14 both confirms a political awareness and agree with the notion given by other interviewees that the public service should provide such capabilities. However, as perhaps intuitively expected from a public institution, such investments need to be made with the design of being publicly accessible. Again, the aspect of technology neutrality and system independency activates and complicates municipals' and the government's situation. Furthermore, the political interviewee elaborated that such investments most preferably seeks to be feasible for several applications controlled or managed under public affairs. Consequently, infrastructure systems capable of fast-charging both buses, refuse trucks and other vehicles working under public registration would ideally be built with the same

standard to enable high utilization and sharing of investment costs. Unfortunately, such synergies may be difficult to ensure when the level of standardization among actors for a new technology usually is low where everyone attempt to develop their own solutions.

Between municipals or regions, the level of competitiveness and prestige in PR and publicity is of less importance. Instead I14 witness about a shift towards more collaboration than before:

"If Stockholm figures out a good idea, fine, what good can we learn, and can we do the same? Instead of sitting at home and trying to invent something even better. And there has probably been a shift, I think it was a bit more so before that you strictly drove your own race. The ticket systems [within in public transport in VGR] are such a bang on example of where everyone has designed their own small solutions which makes today's ongoing integration a nightmare".

Simultaneously the regional splitting in Sweden threaten to make the development to happen unevenly fast. Undertaken actions to prevent such unevenness include interregional collaborations:

"The big regions such as Malmö, Västra Götaland and Stockholm have very close cooperation, I would like to say on many issues. Not least, I think, in terms of meeting new technologies." (I14)

When asked about available control means, the interviewee frequently referred to undertaken environment and climate strategies. Such objectives and strategies are regionally determined and guide the region's municipals when facing decision-taking and managing their operations. The objectives and strategies also govern the demands and requirements listed in procurements, hence indirectly steering the technological development as a customer. However, the undertaken strategies can also have the reversed impact on technology diffusion. As I14 describes; *"Our incentive to drive renewable is basically equal to zero, we do not need any motivational carrots because we have already reached those goals."* and refer to the climate and strategy objectives set for the public transportation in VGR which already has been fulfilled by large.

To be an important tool for bringing stability as described above as a municipals' and legislators' key role in innovation systems, long-sightedness is essential. Consequently, the flexibility is infringed where regulations and laws may directly block inventions and technological advancements to reach commercialization. With regards to this, I14 stressed the fact that public authorities do the best they can to avoid such situations. In the case of emobility, certain, (though in the interview unspecified), regulatory adjustments where explained as theoretically feasible to establish. To achieve such actions, involved actors are encouraged to cooperate and mutually put pressure through a trade organization.

4.4.3 The aspect from university

Insights on emobility from the university domains were acquired through an interview with an associate professor within electric and hybrid vehicles and moreover vehicle expert at the national center for R&D of electric vehicles and charging infrastructure. The information retrieved has mainly been considered as a mean to triangulate and confirm findings from the three other stakeholder-categories.

Findings from the university lector confirm to the largest extent the interpretation given from previous stakeholders in the system. The interviewee especially established refuse trucks as suitable applications for electric trucks with the same reasoning as customers – predictability of routes and frequent start and stop-driving. Furthermore, the importance of political policies was emphasized. Here, I12 derived made investments in electric vehicles, historically limited to buses, to PR of municipals. Simultaneously, the PR-value were emphasized as lower for refuse trucks due to not being *"the flashiest thing"* (I12).

The importance of political incentives and policies is another characteristic previously identified from interviewees which is confirmed by the university point of view. Nonetheless, the role of municipals was by I12 predicted to be limited to the early diffusion-stages of electric heavy vehicles:

> *"The market will go in that direction eventually, but it will take longer time unless municipalities interfere. But I have a hard time believing that these niche markets [referring to city buses, refuse trucks, city distribution] won't choose emobility by themselves, since it probably is the cheapest way to perform the job."*

Furthermore, I12 denoted political policies as the key enabler for realizing the value propositions as identified by all the other interviewees:

> *"When it comes to noise and emission reduction, only one actor can ensure that such carries a value and that is the state or the municipality. Thus, the public can introduce fees that reflect external costs. Then it becomes valuable but traditionally, it possesses no value."*

When asked about perceived barriers against adoption and necessary efforts to undertake to reach commercialization, the interviewee directed the entire answer towards costs with the same TCO-reasoning as all previous interviewees. However, I12 brought a new dimension by emphasizing the necessity of manufacturers' willingness to take higher risks without adding unreasonable supplement charges to make the technology affordable to purchase also in the early stages. A second dimension was also added, i.e. that of the cost-hunting being two-sided which mean that the emobility technology isn't only getting cheaper, but the combustion engine is also expected to be more expensive to operate due to tightening regulations. A knowledge gap was also expressed as a barrier against adoption, especially in public affairs:

> *"There's a gap where the procurers don't know the systems well enough, meaning there's a risk that they don't dare to invest or get poor procurement documents."* (I12)

The interview ended with the interviewee explaining universities' and research institutes' role within emobility. First and foremost, the role as a hub connecting technology, business and research was explained. In I12's view, universities and researchers initially fulfill an important purpose by driving the technological development as a whole. Once the technology reaches a certain point, firms take over and accelerate the development and commercialize while researchers start focusing on fine tuning and in-depth development. Secondly, universities were explained to carry the role as a second opinion where firms may carry out their own (yet similar) agenda as researchers and thereafter use the scientific community as a benchmark for their own efforts. Additionally, universities in general and researchers in particular were explained to often undertake role as mediator between businesses and the public sector where the words of an independent part are of utmost importance for impacting politicians and generate policies.

4.5 The economic characteristics of emobility

TCO refers to a calculation of the total cost of owning something during a set period of time. According to all interviewees, such calculations were always made when pre-evaluating a potential investment. The result was even considered as determining when faced with a purchasing decision.

Figure 7 and Figure 8 visualize the outcome of performed TCO calculations by comparing the cost distribution over five parameters[7] for the 41 unique vehicles included in the study. The calculation is based on data from real refuse trucks in operation driven with a diesel engine. The vehicle data contained parameters as mentioned in *3.3.2 Secondary data* whereas it was possible to calculate the energy necessary to operate each vehicle and concurrently dimension the battery capacity needed if driven electrically. Notable is that several costs have been excluded in the model after been assessed to be the same for operating both types of trucks. Examples of such non-vehicle related costs include salaries and fees for employees and insurance. Additionally, the calculation doesn't include the cost of mounting a body onto the chassis or any governmental subsidies and stretches over a five-year period.

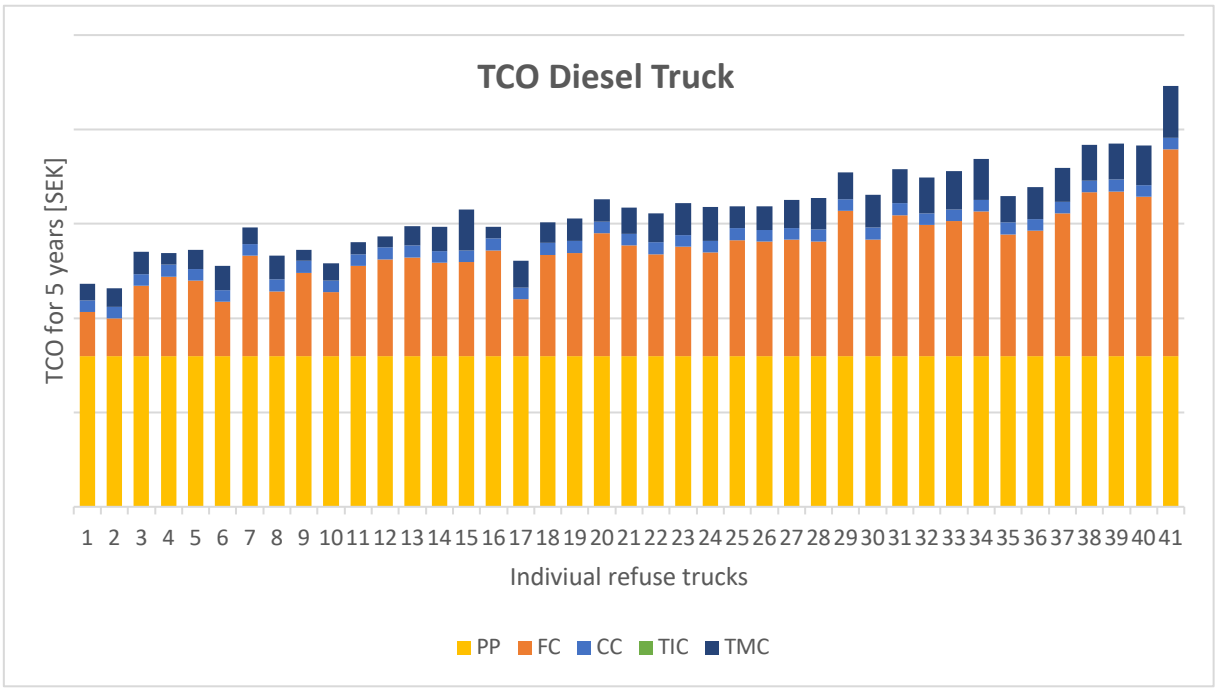

Figure 7: TCO calculation for 41 refuse trucks with a conventional diesel driveline.

[7] PP = purchase price, FC = fuel cost, CC = cost of capital, TIC = total installation cost, TMC = total maintenance cost, TP = price for electric truck without battery.

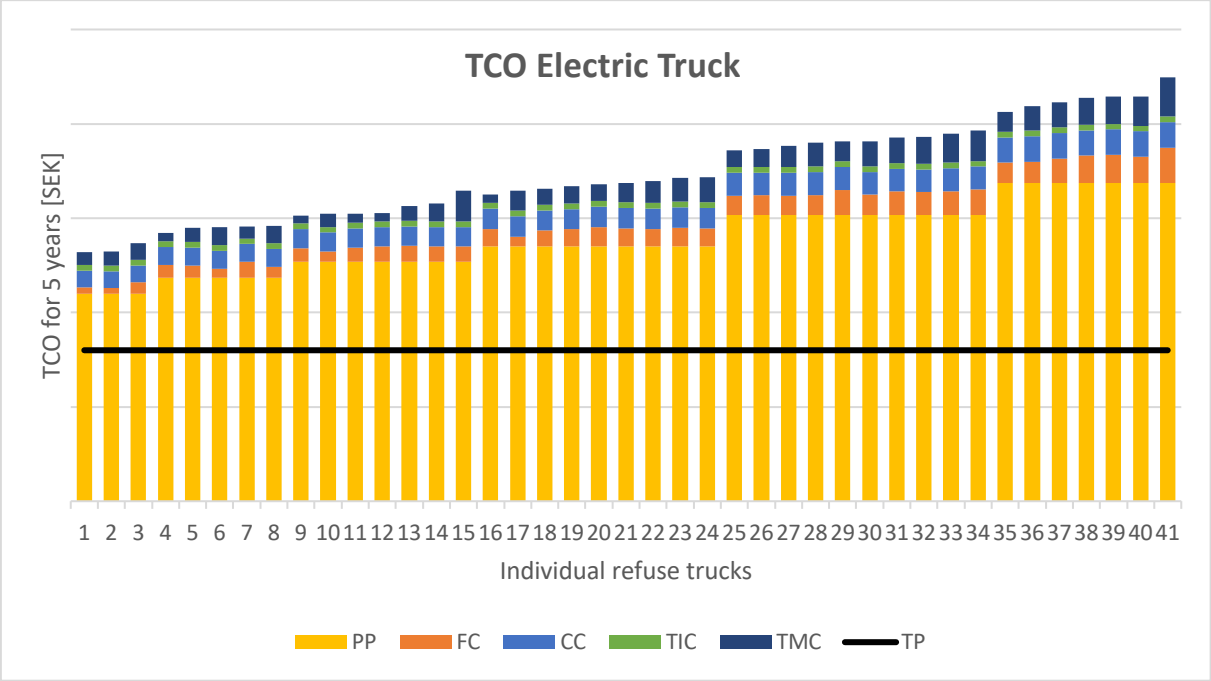

Figure 8: TCO calculation for the same 41 refuse trucks as in Figure 7, but with an electric powertrain.

The TCO modelling and scenario-testing performed in the study indicate that the TCO for an electric truck come close to the diesel trucks around 2019's predicted battery price at 1700 SEK/kWh (200 USD/kWh; (Curry, 2017)) with today's price level on other parameters such as diesel and chargers. The necessary batteries are also the item pushing the purchasing price to become much higher for an electric truck than a diesel truck from a customer perspective and can reach up to 50% of the purchasing price for an electric truck. Simultaneously, the graphs indicate an almost free operation of the electric vehicle since the diesel fuel is being replaced by electricity which is a much cheaper source of energy.

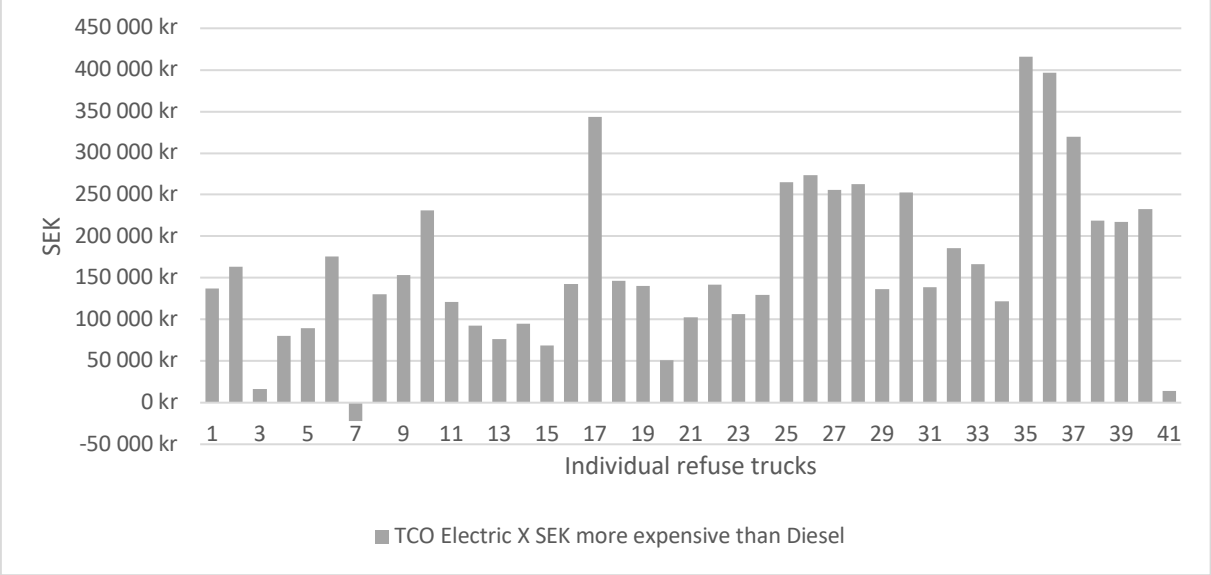

Figure 9: Comparison of each vehicle's TCO-deviation from a diesel powertrain if driven electrically instead.

The observant reader may also notice a lower maintenance cost for the electric powertrain than the diesel's. Since electric trucks is non-existent today, this post's accuracy is less reinforced and more built on speculation and prediction. However, information from Volvo, where knowhow exists in the corporate group thanks to Volvo Bus's experience of electric buses, indicate a reduced need up to 25% for service and maintenance for the electric powertrain. That apprehension is further shared by experts where e.g. Morris (2015) declare electric powertrains as simpler and easier than diesel dittos, hence requiring less costly maintenance.

Compared with the diesel powertrain, the electric creates a new cost post, i.e. the installation cost which refer to the setup of chargers. Adapted to the responses given by customers, the calculations proceed from the notion that night charging is sufficient. CC, i.e. the cost of capital is another post differencing between the powertrains. By referring to the alternative cost for investing in the vehicle, the higher capital cost for the electric truck is explained by a higher investment cost, hence more tied-up capital.

5 Analysis & Discussion

In this chapter, empirical findings are synthesized and linked to the business model framework adapted from Clauss (2017) and supporting theoretical concepts included in the frame of reference. The analysis chapter constitute of two parts. First are the empirical findings synthesized where answers from interviewees are summarized, interpreted, connected and concluded. Secondly are the synthesized findings analyzed through the lens of the theoretical framework to answer our study's research questions one by one. After treating each research question, the found business model implication is summarized and added to a reoccurring illustration. In the very end of the analysis and prior to the concluding chapter, our notion on emobility's implication on business models is summarized via that full illustration.

5.1 Synthesizing customer insights

The synthesis starts with customer insights and thereafter structurally follow the headlining in *Empirical findings*. The only deviation is all external stakeholders being consolidated into one synthesis.

5.1.1 The perception over value propositions

The value propositions emphasized by interviewees in the customer category when asked what change emobility would bring regarding value propositions were found in Table 6. Obviously, an environmental aspect was treated by all respondents, though with variating significance. Some interviewees enthusiastically regarded an adoption of electric vehicles as a highly natural action of their business due to the technology's climate friendly reputation. Simultaneously, some interviewees were more business development-thinking and referred to emission-free transports as an opener of operational opportunities rather than a PR or branding issue. Such opportunities included e.g. start driving in the city earlier in the morning or later in the evening thanks to the reduced noise levels. Concurrently, other limitations hindering such benefits were found such as noisy garbage barrels.

Notably is that the question regarding perceived value propositions with electric vehicles appears to have been interpreted to highlight the difference from today's combustion vehicles. Upon reviewing the interviews and cross-checking them with today's propositions figuring in manufacturers' business models, major aspects such as reliability, ensured uptime and a functioning aftermarket were all found to be assumed as judged from the undertone of the talks. Consequently, the propositions specified in Table 6 rather indicate the association from customers on emobility, whereas just mentioned factors are not to neglect.

Many of the specified value propositions are analyzed to be somewhat obvious with a clear reference to either emission-free vehicles or noise reduction. Though difficult to confirm, a suspicion is raised that the participants may be influenced by prejudices and impressions from the electric passenger car industry. In other words, the knowledge-level regarding electric trucks was perceived to vary among the interviewees. Upon subcategorizing within the

customer category, a pattern is distinguished where interviewees representing companies with a larger base of customers constituting of firms than municipalities tended to appear more versed within emobility. Everyone who took the proposition aspect further than an emission-free or quieter operation, i.e. I4, I8(a+b), I10 and I11 all represented companies with such characteristics. These respondents were also the ones more positive to be able to monetize from the new value propositions since a higher interest to pay for reducing the environmental impact, mostly for PR-reasons, were sensed from the private sector.

5.1.2 No problem with a shifted cash flow

The synthetization over customers' inputs to financial barriers for adopting electric trucks conclude the important insight that the vehicle's TCO is the most important factor in a purchasing decision. Here, no distinction is found between public sector or private companies. Additionally, it is reported that a new monetary arrangement with a higher initial investment followed by a very low operating cost isn't perceived as an obstacle.

Neither is it considered a problem to finance the down-payment, hence erasing the need of inventing new financing arrangements. However, there is no "one model fits all" in the industry and companies see different values in owning, renting or leasing their vehicles. Clinging on to that finding, none of the interviewees reported any necessary changes to be made but were satisfied with the arrangement they utilize today. Based on those responses from customers, the verdict is that customers want to have the same ability to choose their preferred type of ownership as electric trucks are introduced.

Linking back to customers' perception over value propositions, it's further noted that the TCO won't find much help from increased revenues and thereby ease the cost level demands.

5.1.3 Customers' requirements for adoption

When summing up the input given from customers about their requirements for running their operations with electric vehicles, it is concluded that the answers have been overall consentient. Some requirements were explained as sharp and necessary to be met while others were of a more desirable character, i.e. possible to be without in favor of other benefits such as lower costs, competitive advantage etc. Findings which lead to both these conclusions are that all respondents demanded a full day range capacity for their batteries. Simultaneously, most interviewees added that they are adaptable to whatever solution the manufacturers propose. However, especially the representatives from distribution companies addressed the question about a public charging infrastructure accessible to enhance the flexibility of their vehicles and take height for unplanned transportation needs or seasonal variances. Such an infrastructure was however not expressed as an explicit demand but rather as a challenge to address if lacking.

Most interviewees from the customer segment also expressed previous bad experience from testing new technology and vehicles which raised skepticism for emobility. Most concerns regarded components and their performance beyond truck manufacturers' current domains, i.e. the battery or charging system. The researchers did however notice that several concerns

weren't aligned with the accurate technology status but instead seemed to be based on rumors or prejudices. Typically, several interviewees established a notion that electric vehicles were far away which is, at least from a technical point of view, a faulty perception confirmed not only by the words of Volvo but also by the introduction of an electric refuse truck in Gothenburg (Göteborg Stad, 2018).

Despite above skepticism, a willingness to collaborate and co-develop the technology was interpreted among the respondents by the researchers. Especially recycling companies appeared eager when proudly announcing their business to becoming a popular channel for launching new technology. The representatives from distribution companies appeared more bided and referred to larger cross-industrial incentives between research community, government and the business world as their collaboration-efforts. Additionally, these interviewees also emphasized cases of successful application before transcending in any larger scale as necessary.

5.1.4 Services' role in the truck industry

The investigation over services' role in the truck industry conclude that the aftermarket is perceived as an incredibly important part of a vehicle purchase and ownership. The prospects for functioning service which deliver uptime were a dimension targeted by all interviewees which also link to the perception of value propositions. A willingness to pay for such services is also revealed due to the respondents declared service contracts. Additionally, vehicle manufacturers providing an extensive functioning aftermarket appear to have become an institution in the industry, i.e. some norm customers expect and regard as an order qualifier.

Financial services in terms of leasing or renting agreements is another type of services concluded to be utilized. Upon analyzing, the tendency regarding such arrangements is that the larger companies undertake a mix of leasing and owning while smaller operators tended to own the vehicles by themselves. A distinction between what vehicle brand the interviewees' company operated didn't make a difference either, i.e. leasing arrangements could be sourced independently on who the manufacturer was. However, a raised concern was the suspicion that the manufacturer might add high margins due to the increased risk-taking which made such financial services less attractive.

Though the interviewees and empirical findings mostly report on services linked to service and maintenance of the trucks, digital services also appeared in the answers. The diffusion of digital services was however found bounded exclusively to fleet management reports where the internet connected truck collect data which are compiled by the manufacturer and sent as information. Additionally, no distinction was made in the usage of fleet reports between the applications – both refuse and distribution vehicles utilized it. As the digital services were declared to provide control and material for precautious actions, the interpretation from the researchers is that the interviewees appeared interested in adding more services to their vehicle. Features enhancing the driver's environment, work process or safety are all areas which were mentioned as important in the daily operation. Though no specific concepts or proposals were proposed, the area of digital services definitely appeared underutilized.

5.2 Synthesizing external stakeholder-insights on emobility

Insights from stakeholders in the system of electric trucks both confirm and bring in new perspectives beyond the manufacturers' customers. First and foremost, the interviewee from the energy sector also addressed the importance of political policies to realize the diffusion of emobility. The importance of political incentives where furthermore confirmed as well recognized by the interviewee representing politics. Simultaneously, the factor of technical neutrality was introduced as a necessary dimension to consider when campaigning for governmental interventions. In other words, the reality is much more complex for the public authorities who cannot benefit innovations freely but have to ensure fair competition conditions. Though, exemptions from the current legislation where found possible to allow, which may play an important role regarding e.g. loading and weight limitations which was raised as a concern among operators.

Findings from the energy sector mainly concern the dimension of charging and an infrastructure for providing such opportunities. The synthesis highlights the given notion that the energy industry has remained somewhat passive which has opened up business opportunities and the emergence of new actors alongside the traditional suppliers and grid owners of electricity. Upon observing the empirical reality, the forming of a new ecosystem is confirmed. Not least with actors such as ABB or Siemens developing, building and offering charging equipment for both public and non-public applications (ABB, 2018; Siemens, 2018), which is sold to local grid owners such as Göteborg Energi who operate the infrastructure in the area (ABB, 2017). Concurrently, there are efforts from the automotive industry to broaden its scope by forming joint ventures to seize the opportunity for new revenue streams and give the technology increased functionality.

The prospects to find profitability in providing and running a public charging infrastructure where found difficult for any actor due to a too small customer base. Instead, the incentives for electricity companies to commit to emobility projects where mainly associated with PR and sending a message of innovativeness. As an independent party, the interviewee from university didn't only confirm the impressions retrieved from each category of stakeholders, but also established the public sector as the most important institution to secure a monetary value on emobility and its advantages. Especially to prove the applicability until the market organically find its way to the technology.

5.3 Synthesizing the economic characteristics of emobility

When talking to customers it became clear that the most important factor for a vehicle purchase is the TCO. Margins in their businesses are low whereupon being able to lower cost is crucial. This indirectly decides what cost level electric trucks must reach or how much a truck company can charge for their trucks. It's also important to recognize that although an electric truck brings other befits such as environmental, this is not something truck customers can pay more for since they can't charge their customers more for these benefits. They might be able to buy one truck to try the new technology and see the extra cost as PR. But they will not change the entire fleet until the costs are equal, lower or they get paid more. Since customers are calculating TCO carefully before a purchase, it's also not possible to get a customer to opt for a different financial solution that is more beneficial for the manufacturer if there are no additional benefits for the customer. In other words, manufacturers have a difficult time getting customers to pay a lot more for the additional risk manufacturers take with operational leasing.

When examining the costs for a diesel truck, a large share of those costs are fuel costs. When transitioning to an electric driveline these costs will be replaced by battery costs, electricity and depending on preferred charging type, a charging station. Depending on what battery size is needed the cost of the batteries can make up to 50% of the purchasing price of the truck. Consequently, manufacturers can expect a large increase of monetary exposure to their customers if all these components are sourced through them, hence creating the challenge of adding value and capture revenue on this monetary exposure.

It is also expected that electric trucks will require up to 25% less service and maintenance, due to electric engines being a simpler technology than their combustion counterparts. This is good for the users since they will not only spend less money, but also reduce their vehicle's downtime and hours spent at workshops. For manufacturers and workshops this implies that they can expect a reduced revenue stream from aftermarket but potentially also enable new types of arrangements or ways to deliver their value.

5.4 Addressing the research questions

The following subchapter directly address the research questions through in-depth analysis and discussion over the empirical findings and synthesis. Instead of following the value dimensions in the business model, we structure our analysis through certain key themes in which the business model implication is treated. After treating each research question, we summarize our reasoning over business model implication in an illustration which reoccurs and successively build up our full interpretation as illustrated in Figure 16. The impacts in the illustration are presented through the dimensions of value proposition, value creation and value capture, hence structured as the business model framework of Clauss (2017).

5.4.1 RQ2: What interest and role do stakeholders downstream the value chain have in emobility and how may these affect the existing business model?

The found interest in electric trucks among this study's interviewees is concluded to have been both vast and deep. All interviewees have given well-briefed insights to the technology with a generally homogenous plan for implementation. Though, as highlighted in the synthesis above, some differences were retrieved from the respondents, not least within the customer category which might influence the business model of truck manufacturers. The analyzed impact on each value dimension as emphasized in this subchapter is summarized in Figure 10.

5.4.1.1 Room for educating stakeholders and society about emobility's all benefits

The value of emission-free trucks has been warmly embraced by all interviewees from all categories which in one way is a fully correct anticipation, but simultaneously overlook many other benefits with an electric powertrain. Not least has customers left out the factor of increased uptime due to the decreased service and maintenance need that comes with the simpler machinery from their answers. Such a finding is interesting since uptime is highly emphasized in the current arrangement with both service contracts and importance of repair shops nearby. Consequently, there appear to be an underutilized potential for increasing the welcoming by educating customers and shine light upon such positive effects for their own operations.

Activities for informing the society in large and perhaps raise a demand or at least a positive public opinion to electric trucks is another impact emobility can have on manufacturers' business model. The underlying reasoning leading to that conclusion is that the adoption of electric trucks is found to be highly dependent on its TCO where new value propositions won't monetarily benefit truck manufacturers' customers by enabling to charge more from their customers. Instead, the only extra value at this stage is of PR-character, both for municipalities and companies, whereupon it may become important for truck manufacturers to ensure that PR value through public campaigns. To bring credibility to such efforts and avoid the notion of simple advertisement, alliances with universities and trustworthy organizations will be important partnerships to establish and thereby affect the dimension of value creation as conceptualized by Clauss (2017).

Alongside a raised awareness over emobility's feasibility and benefits, it's possible to depict a situation where a new kind of customer base might arise. Not least within the distribution segment where companies with a lot of transports in their businesses, e.g. by offering home delivery, may perceive emobility to enhance the company's sustainability strategy and therefore invest in a fleet of their own as a differentiator. With raising consumer demand of door-deliveries of everything from daily grocery bags to furniture, the situation where companies in densely populated areas are able to fill their own transports and not engage a carrier to maximize the transport's payload is very possible. An extra dimension speaking for such a development is companies' chance to retrieve customer feedback unfiltered directly into the organization, i.e. without the detour through an external carrier. The business model affect will naturally be a widened customer base with a higher leaning to pay for the environmental benefits, thus affecting the 2nd order dimension "Customer segments & markets" in the value proposition dimension (Clauss, 2017).

5.4.1.2 Level of vertical integration as a strategic question impacting the business model

The transition to an electric powertrain imply that the TCO will become dependent on a new supplier network with the battery manufacturer as a major actor, which raise several strategic crossroads for the incumbent truck manufacturers. By vertically integrating upstream the value chain and undertake an own development and production of batteries, manufacturers can reduce interdependence risks as emphasized by Adner (2006) and Williamson (1985). Not least can uncertainties regarding an external battery supplier's ability to deliver its contribution to the development be decreased. Naturally, such vertical integration doesn't only require enormous investments in plants or new competence, it also allocates a larger portion of risk to truck manufacturers and the requirement to perform better than current battery producers. And in times where there still might exist hesitation whether batteries or which battery technology will be the dominant design in powering trucks, the authors of this thesis have a hard time picturing all incumbent truck manufacturers to engage in battery production at an early stage. Instead, close partnerships and joint development with a battery supplier is probably the impact most incumbent truck manufacturers will experience in their business models. Such partnerships will however be crucial, not least when taking into consideration the options emphasized by Adner (2006) and allocate resources to overcome the battery as a bottle neck hindering the TCO from reaching a comparable level to diesel trucks. Upon establishing such partnerships, the three factors emphasized by Bierly III and Gallagher (2007) that make it difficult to create good partnerships in a business model, i.e. strategic fit, trust and uncertainty and time, need to be considered. In terms of strategic fit and trust, it's of importance to locate a good fit with suppliers where both parties benefit and gain as much knowledge as possible to avoid having to rely on trust when taking decisions since trust give no guaranties. From the time aspect, these long-term partnerships shouldn't be rushed into, since that seldom leaves appropriate time for a rational decision from a well-considered process, thus lowering the chances of choosing a supplier with the best strategic fit.

Another strategic question for truck manufacturers to resolve is how to ensure a charging infrastructure in the future which risk to become a complementor limiting the adoptability of

battery powered vehicles if lacking. Though interviewees indicate that such infrastructure is of less importance for refuse trucks and early city distribution, charging capabilities will eventually be necessary to provide for applications outside cities unless very radical breakthroughs are being made in the battery technology and batteries' energy density. The notion received about a fairly awaiting energy sector creates an opening for manufacturers to expand their business scope as an alternative to partnerships as mentioned by Mäkinen and Dedehayir (2012). Here, the strategies appear to take apart where some incumbents have started forming consortiums to build charging stations (though mainly targeting passenger cars). Others such as Tesla develop, build and operate themselves while some rely on second parties to develop and build the charging posts. Simultaneously, some actors from the incumbent energy sector make efforts to acquire a share of the growing market.

Regardless of which strategy truck manufacturers decide upon, charging infrastructure will definitely have effects on the business model. Relying on external development and operation may restrict manufacturers to compete in some regions if charging possibilities for the customer is absent. In other words, available markets to offer and sell electric trucks in may be influenced similar to how policies may affect the same. Effects on the business model will also occur if the strategic choice to develop, build and operate charging stations is taken. From a value proposition perspective, such an undertaking would imply the possibility to offer a total solution to the customer and e.g. charging procurements as emphasized by the interviewee representing the energy sector. Additionally, it would bring control over available markets to a larger extent due to less dependency of external providers' interests. In terms of value creation, the expansion into charging infrastructure would require new competence and adapting the organization towards such new activities. Naturally, new suppliers would be added to source components if not manufactured in-house. Monetarily and within the dimension of value capture, operating charging stations would open up for new sources of revenues, both from own customers but also from operators driving competitors' trucks. Additionally, new types of offerings, e.g. loyalty benefits or discounts could be enabled to attract customers.

The decisions on above strategic issues and whether to vertically integrate or disintegrate in the value chain will naturally also impact which processes and structures to include in the business model to deliver targeted value propositions. Truck manufacturers who decide to include charging infrastructure or battery production in the business (depending on what level of course) will need to set processes and structures for R&D, operations, manufacturing etc. On the contrary, manufacturers deciding not to undertake such efforts will be exposed to a higher network dependency and less opportunities to increase margins through potentiation. In the long run, the relevance of truck manufacturers may risk becoming limited to figurate as an assembler of sourced parts and branded under a certain name. Thus, the added value by the future "manufacturer" will be low and subject for rationalization which historically has shown to be devastating for actors whose industry is affected by technological impact. Though not fully the same as this study's context, the entrance and challenge made by Uber in the taxi industry is an excellent example how traditional institutional structures and consolidating arrangements, in this case taxis, suddenly struggle in a new technological arena (Cramer & Krueger, 2016).

5.4.1.3 The political arena as a key actor

Naturally there are truck applications such as regional and long haul which eventually will be heavily dependent on a public fast charging infrastructure. But, refuse operators' found interest in emobility with revealed favoritism for night charging increase truck manufacturer's independency from other system actors to deliver a functioning product. Consequently, the risk of mistiming by offering a product constrained by immature complementors beyond manufacturers' control as emphasized by Adner (2006) is analyzed as reduced. Additionally, interviewees' concluded eagerness for co-developing the technology enable a test arena to generate a proof of concept which could impact other customers' opinions positively, not least distributing companies who indicated more need of such proofs. However, from a political point of view, the risk for mistiming is larger due to already fulfilled climate goals and thereby lowered incentives for regions or municipalities to demand the technology in their procurements. Of course, public procurers cannot demand a non-tested technology, hence making pilot projects and proof of concepts with early adopters even more crucial.

Combined with having all respondents emphasizing politicians as key players for diffusing emobility, the fact above means that activities and relationships with governments, municipalities and public authorities is another impact emobility is expected to have on manufacturers' business model and the dimensions of value creation and propositions (Clauss, 2017). Though not a novel feature in itself, the magnitude of its significance will most probably be higher in nearby future business models, not least for the segment of refuse trucks where truck manufacturers' customers adjust to procurement demands set by politicians. Approaching the public sector similar as customers with education and involvement in the practical implementation are key activities analyzed to boost emobility's spread and commercialization.

Insights from politics reveal two more implications on existing business models. First, the aspect of technological neutrality may force truck manufacturers to ensure a certain level of competition to avoid being alone with an electric offering. Such cautions force involvement in interest groups containing other manufacturers and other stakeholders such as customers, public authorities and infrastructure providers (i.e. the entire network system). Transparency and openness is considered especially important in this early phase of commercialization of electric vehicles to ensure the technology's relevance for the future, but also to spread information and knowledge as previously emphasized. Secondly, politically established policies can realize the value of the novel value propositions that comes with emobility, hence synthetically create a demand which may direct what markets or geographical regions truck manufacturers can compete with electric trucks. The business model effect from today is thereby a narrower targeted customer segment since a globally widespread diffusion to all markets and application areas is ruled out. Especially in the early stages when subsidies and complementing infrastructure is needed to both economically and practically enable the adoption, hence implying a strong network dependency of intangible value as argued by (Allee, 2003). Figure 10 summarize the business model implications found in this subchapter. A dashed outline indicate that the implication depends on a strategic choice while a solid outline mean that the implication is perceived applicable to manufacturers in general.

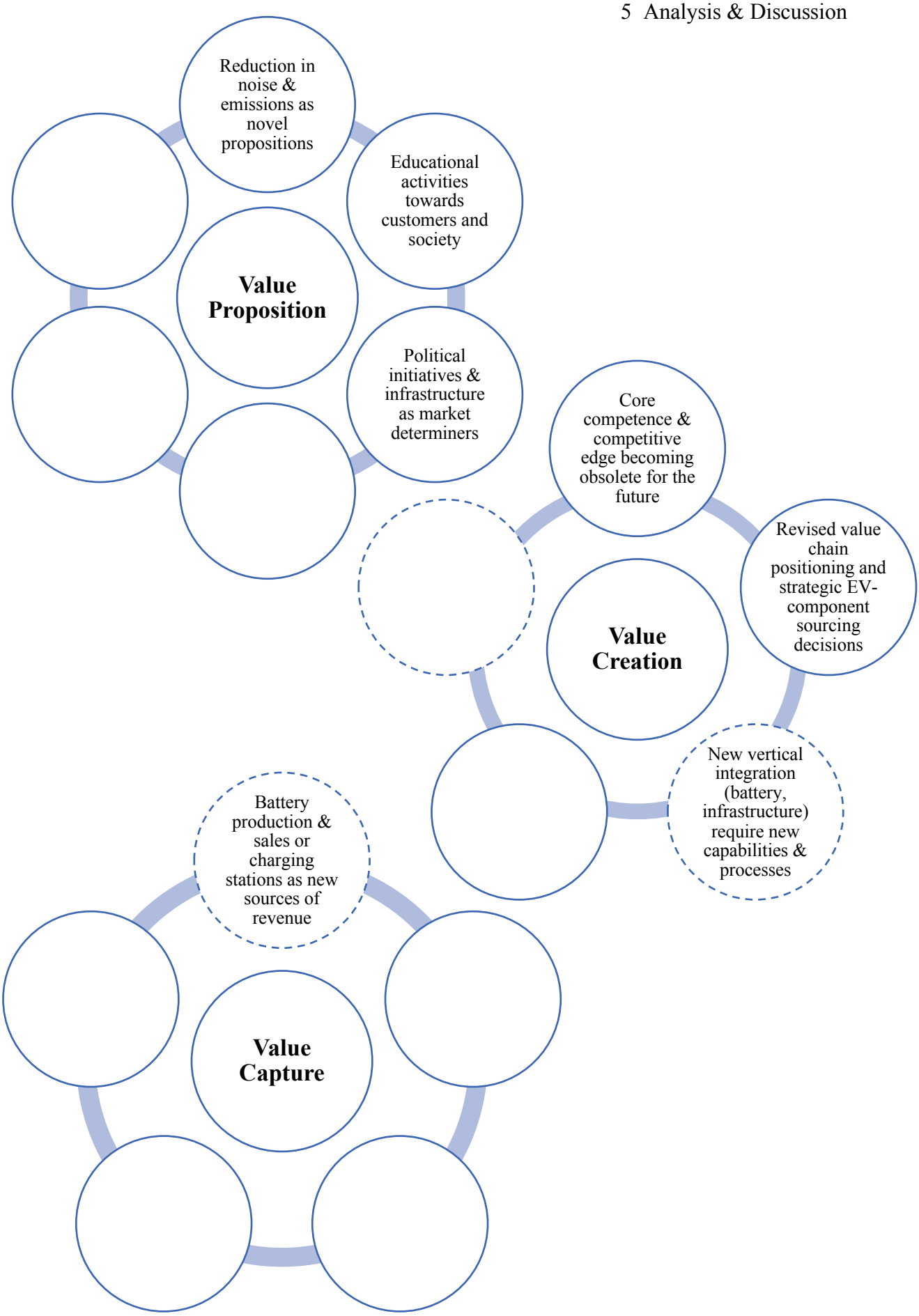

Figure 10: Summarizing illustration over emobility's impact on each value dimension in the business model framework as emphasized after investigating research question 2.

5.4.2 RQ3: What is the potential for servitization and how would that influence the existing business model?

Much emphasis of emobility's implication on incumbent manufacturers circulates around strategic choices over what parts of the new technology to control in-house, a presumed decreased aftermarket with reduced revenues and new value propositions with limited monetary potential. Simultaneously, the phenomenon of servitization has breached into the truck industry as emphasized in the literature and empirically found particularly established in the aftermarket. However, emobility may very much affect services' role in the truck industry, not least in importance as a source of revenue.

5.4.2.1 Batteries bringing opportunities and impact on the existing service arrangement

Societies' raising environmental awareness create opportunities to achieve recognition for positive emobility-aspects which could be utilized as offerings in the business model. With circular economy as an emerging buzz word, i.e. where the entire life cycle of products from raw material to recycling and reuse is ensured, we perceive a future market for second life batteries as an obvious example of such business opportunity. Though not explicitly investigated in this study, customers' announced interest for trucks with as low environmental impact as possible hints that such circular economy-related offerings might come to be capitalized on and included in the offering portfolio of truck manufacturers. In the case of batteries, the possibility to include sustainable disposal and refurbish used battery packs in the sales agreement as a service would not only be merciful to the environment, but also offer an even more climate neutral alternative for customers to expose to gain goodwill. Such strategy would furthermore be a way to source the aftermarket with cheaper second-hand batteries. The latter would be beneficial to truck owners since they wouldn't be bounded to buy expensive new batteries with an expected life time of 5-7 years when he only wishes to operate the vehicle for two more years.

The value capturing for batteries will initially most likely be included with the vehicle since manufacturers may regard both themselves and the market as too immature to subcontract that important part. Customers' outspoken preference of smooth ownership and few supplier contacts are additional findings supporting that conclusion. However, another arrangement one could imagine emerging with time is a separation of batteries from the chassis where batteries becomes possible for truck operators to source independently of a truck manufacturer, e.g. by renting directly from battery manufacturers or third parties. Not least for second hand batteries to avoid the mismatch with new batteries mounted on an older truck. Such renting activities is not only well aligned with the circular economy-argument yet wouldn't require too much adaptation from today's business models. Even if the operation would be logistics intensive and require competence regarding the battery to refurbish them safely and successfully, our anticipation is that incumbent manufacturers such as Volvo with an extensive dealer network are well equipped for handling those activities. The biggest impact on incumbents' business models would instead be within the value capture dimension due to entirely new revenue streams as a countermove to decreased maintenance revenues. The offering of cheaper second

life batteries would also ensure a more stable or lucrative aftermarket for used electric trucks, hence helping the TCO by providing an increased residual value. To successfully enable such offerings, some form of standardization of battery packs and their interface would be necessary, hence initially affecting the manufacturers through collaboration between firms to decide upon such standards.

Potential renting arrangements do however possess large backdrops for the manufacturers. Renting made by other actors implicate less cash exposure from the customer to the manufacturer, thus reducing the amount of money to add a margin to. Renting carried out by the manufacturer would bring the negative aspect with unfavorable cash flow since high and early payments is financially beneficial with possibility to make interest bearing. Consequently, as long as the TCO is positive and the upfront invest isn't regarded as a problem, the incentives for such arrangements should be low from the manufacturers' point of view.

Previous research question discusses the issue of manufacturers needing to decide upon what position to take in the value chain. The strategic move each incumbent manufacturer make in regard of supplying their trucks with batteries creates opportunities and impact on the current aftermarket structure. An alternative arrangement to today's full responsibility taken by the manufacturers' or authorized dealers could be that the battery suppliers themselves provide separate battery contracts. Thereby, manufacturers could avoid taking responsibility over components beyond their knowledge and core technology which might be more painful and inefficient than lucrative. However, as a more inconvenient arrangement for the customer with several interfaces to handle, it is analyzed to be more likely that truck manufacturers decide to include the competence into their own service contracts. Not least to avoid having external actors infringing the sacred aftermarket. Manufacturers who decide not to engage in battery production but instead source them from a supplier will of course need to ensure capability and competence to provide a service organization capable to deliver uptime to the truck owners.

5.4.2.2 Digital services as one of three focus areas

Verstrepen et al. (1999) identify threatened or decreased margins as a driver of servitization for incumbent actors. Such a description is determined highly applicable to tomorrow's truck industry where the incumbents lose both control over the core technology and current aftermarket revenues. Naturally, this is something manufacturers has sensed, hence already started to include services in their business to create additional value as described earlier in the thesis. Though not emobility specific, services in general and digital services in particular are anticipated to carry a higher significance to protect companies' earnings. Accompanied by emobility and automobility[8], digital services is one of three legs Volvo express as focus areas for their future (Volvo Group, 2017) where digital development and new technical capabilities may come to work as an antidote for lost core technology and revenue. The implication experienced in incumbent business models will therefore be an offering portfolio consisting of more digital services, not least within the connectivity segment. In this case, connectivity refers to trucks connected and sending real time information through the internet whereas real time

[8] Automobility referring to self-driving vehicles

surveillance over performance and enabling of breakdown-forecasting becomes possible. The value of such possibilities is high since service and maintenance can be optimized for both the truck manufacturer in terms of planning or spare parts supply and the customer be decreasing the number of workshop visits.

The digital development will of course require extensive competence renewal with increased demand for software engineers and IT expertise, thus creating challenges to attract enough talent. Though sourcing of new competence never was emphasized as a problem area during interviews or workshop, exposure to students and appearing at new education programs are activities that will differ from today's. In a longer perspective, the increased importance of digitalization and growing IT departments may come to change manufacturers' organizational structure, hence impacting the dimension of value creation (Clauss, 2017).

Beyond (digital) services' implication on organization, offerings, capabilities and revenue streams, the relation to customers is also anticipated to be affected. As explained, the common setup for manufacturers is to deploy authorized dealers and workshops to reach their customers. Consequently, the relationship to customers are being decentralized locally and loses some of its connection to the headquarters. Through digital services, the relationship between the customer and parent company will be possible to strengthen since the delivery and communication more directly will flow between these two. Furthermore, depending on what kind of services truck manufacturers innovate, digital services might be the way for truck manufacturers to compensate for the lost core technology and upstream disintegration. In long term, digital services may very much imply an integration downstream the value chain and into customers' operations, where the relationship shifts from a truck supplier to a partner. Such a scenario is strengthened by the interviewees' expressed welcoming for closer collaboration with truck manufacturers to optimize vehicle costs.

5.4.2.3 Servitization and digital services generating more than revenue

The heading reveals our analysis that digital services possess other values than revenue. Aligned with the observation from Mahut et al. (2016) on Tesla, data collection in liaison with delivery of digital services creates opportunities which might affect today's business models' processes drastically. Truck manufacturers vertically integrating downstream and becoming more of a partner with the possession of large data sets enable a new sales approach which after analysis and discussion is evaluated as highly probable. Instead of passively offering products to customers or leave specific tenders upon request, possession over authentic vehicle data allow truck manufacturers to approach customers with prepared offerings designed to optimize the customer's vehicle cost. In a first transition phase, such processes are anticipated to benefit the diffusion of electric trucks by enlightening customers to realize the feasibility of electric trucks in their operations, both economically and technically. By helping customers on beforehand with battery dimension, charging optimization and comparing the TCO for both the electric and diesel truck, the effort of investigation, research and contacting is eased from the customer who only need to evaluate and take a decision.

When considering the benefits with TCO modelling as perceived by Ellram (1993) and customers' found emphasis on total ownership costs, the potential scenario of truck manufacturers moving closer to their customers are strengthened. By undertaking the responsibility for demanding operations such as data processing and monitoring, a truck manufacturer's business model can include entirely new value for its customers whose vehicle costs can be minimized as cost saving opportunities are revealed. For customers, integrated long-term partnerships would also allow for lowered pre-transaction costs as the truck manufacturer and customer already know each other as argued by Ellram (1993). By providing this arrangement to all of its customers, truck manufacturers possess the advantage of scaling up an organization dedicated for these processes after which economies of scale and efficiency may be reached in an entirely different way than separate customers may be able to manage. Integrated TCO-modelling wouldn't only bring benefits to the customer, but could also let the truck manufacturer make use of the advantages from Ellram (1993). Not least as support for continuous improvement which could assist the manufacturers in their improvement processes as the database over vehicle performance and patterns grow.

The integration described above could be seen as a middle step towards a business model design where truck manufacturers sells their trucks and products solely as services, i.e. access to a vehicle entirely free from ownership which would be the ultimate level of servitization in the industry. Simultaneously, we argue that this arrangement partly already exists today through operational leasing which customers haven't referred to as particularly interesting. Instead interview data imply that customers are too immature for such arrangements and instead prefer less total servitization, whereas that case isn't treated more in depth than this mentioning.

Figure 11 summarize the business model implications where grey filling refers to previously treated implications while white filling refers to those found in this subchapter.

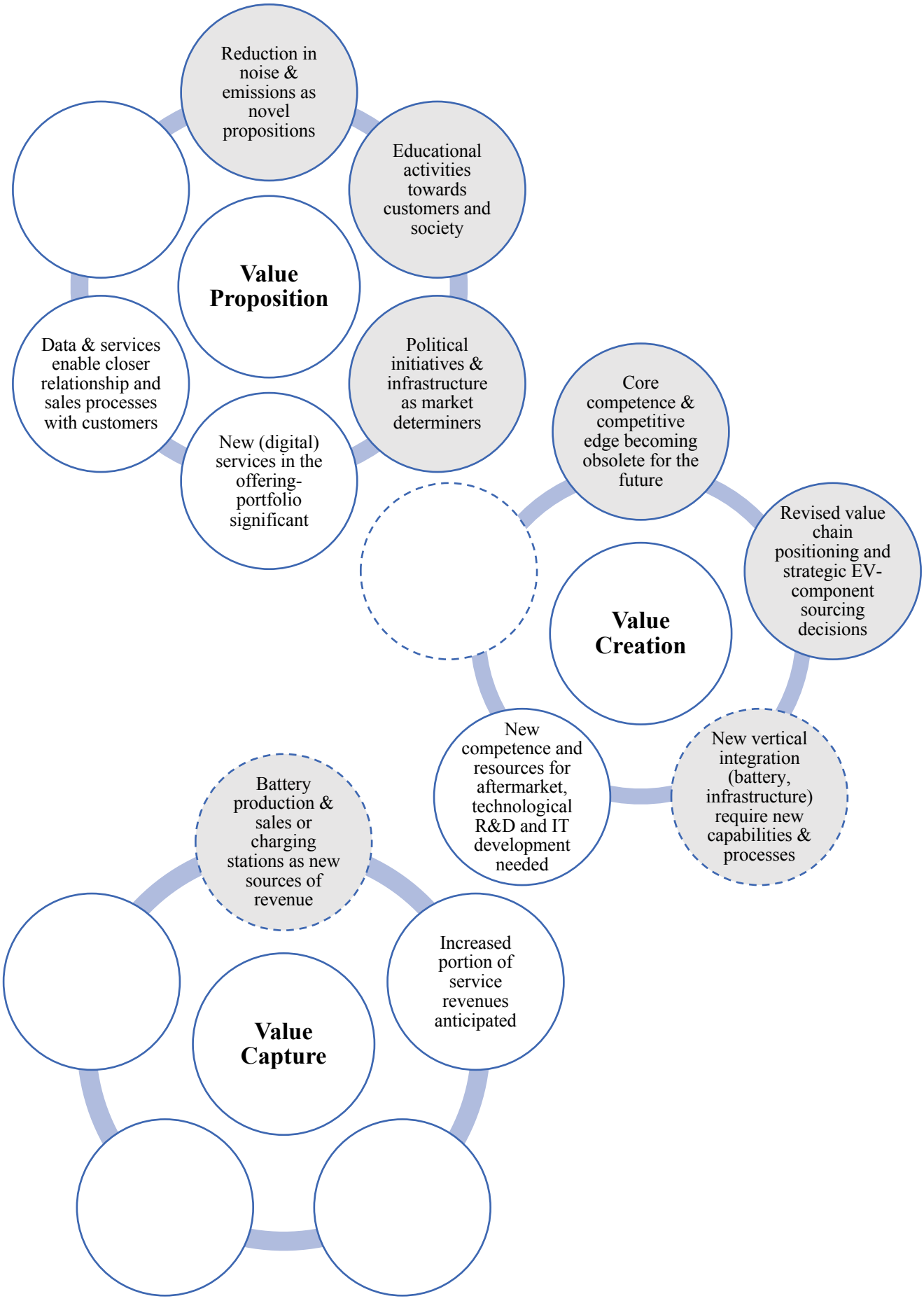

Figure 11: Summarizing illustration over emobility's impact on each value dimension in the business model framework as emphasized after investigating research question 2 and 3.

5.4.3 RQ4: How does the TCO differ between a diesel and electric truck and how does this difference need to be accounted for in the business model?

Customers' most important tool for purchasing decisions is the TCO model. This large focus on TCO can be viewed as an opportunity, since a manufacturer capable of showing a trustworthy TCO equation that is equal or lower than today's alternatives will immediately be in the front seat for obtaining a larger share of tomorrow's electric truck market. For a refuse truck, this looks to occur at a battery price of around 1700 SEK/kWh (200 USD/kWh) as depicted by the study's TCO-modelling. The model does however possess uncertainties were variables such as diesel price, residual value, need of fast charging infrastructure and political regulations and subsides can have large impacts on when electric trucks are profitable from a TCO standpoint.

5.4.3.1 New monetary exposure creates challenges

Fuel costs are a huge part of the costs for a diesel truck where the constantly fluctuating oil price makes it nearly impossible to exactly forecast what the cost will be over a set period of time. For an electric truck this uncertainty and cost post disappear. Instead, batteries will be a new cost item which can make up to 50% of the truck's purchasing price. For truck manufacturers, this creates a big challenge but also a huge opportunity since more of the carrier's truck costs can flow through the truck manufacturer, hence impacting both the business model's revenue and cost structure for truck manufacturers as previous fuel costs instead run through the vehicle provider as battery cost. The paradox is that most truck manufacturers don't produce nor possess their own battery technology. Instead, this is something that is bought from a supplier or partner whereas the added value that the truck manufacturer adds to the batteries can be questioned. Within a competitive market it is difficult to markup something you don't add value to. Consequently, it's possible that the profit will remain the same, while the profit margin is lowered due to higher sales than today. These key performance indicators directly affect the stock market and if these changes are expected, they need to be communicated to investors and owners in a good way well in advance to avoid turbulence.

5.4.3.2 Emobility influencing the aftermarket

An expected 25% decrease in cost for service and maintenance for an electric truck is great for the customer since their vehicles can spend more time on the roads and less time at the workshop. But for manufacturers like Volvo who sell service and maintenance contract for their trucks, this equals an expected decrease in revenue from the aftermarket which immediately affect the value capture and revenue structure. The aftermarket is important today, partly since its profit margins are high, but also since repair shops constitute the important channel for the company to reach out to their customers and give them the service and support they need and require. The dealer network is to a large extent furthermore responsible for the customer relationships during the product lifetime bringing back feedback thoughts from customer. One alternative for manufacturers to minimize the economic loss from the aftermarket and risk of losing the important feedback loop the dealer network brings could be to force all customers to

perform their service at one of their workshops for the warranty to be valid, something that e.g. Volvo don't force today. To realize such demands, truck manufacturers need to make sure to have workshops or that are conveniently close to all of their customers.

A reduced need for service and maintenance doesn't only affect the business model negatively through lost revenue, but also enable new opportunities to create and capture new value propositions. Mobile workshops are such an opportunity that arise from the simpler machinery free from oil and need of sanitized facilities. In practice, mobile workshops would enable an offering where the service man comes to the customer instead of the opposite, hence increasing the convenience and lower the wasted time spent on transportation to and from the workshop. With increased convenience and operating time as value propositions, customers could potentially regard this new offering as something they were willing to pay for. Consequently, manufacturers loss of revenue would be eased. In terms of value creation, entirely new processes would be necessary to establish together with new types of mobile equipment.

Regardless of mobile workshops or not, a large dealer network with service shops would still be a key resource to deliver sufficient service and uptime for customers. But as with many other functions today, these dealers and service shops don't have the necessary knowledge or equipment needed to take care of electric trucks. Naturally, this is a new capability that Volvo and other incumbent truck manufacturers need to diffuse into the network as the new technological paradigm spreads.

5.4.3.3 Sensitivity analysis of the TCO

The diesel price[9] has a huge impact on the cost of ownership and directly affects the difference of an electric and diesel truck. With the oil price so tightly intertwined in the global political stage makes a 20% rise or fall over a 5-year timespan not too impossible. The scenario of such fluctuation is visualized in Figure 12 where such a change would drastically affect at what costs and point electric trucks become cheaper to own and operate than diesel trucks.

[9] Diesel price (Q4 2017) for commercial usage exclude VAT and include a bulk discount (International Energy Agency, 2018).

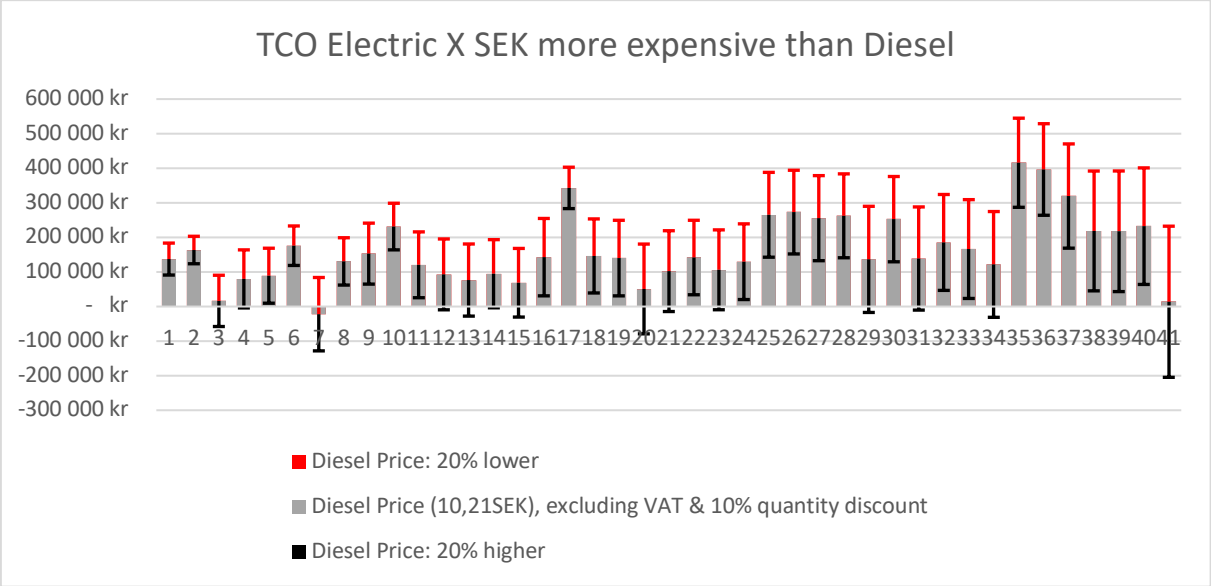

Figure 12: The TCO model's sensitiveness in regard to diesel price

The largest single cost for the electric truck in our calculations is the battery pack, thus a change in the world price would have a big effect on the TCO for customers. The sensitivity is visualized in Figure 13 by investigating a price fluctuation-scenario of +/- 50 USD/kWh and what impact that would have can on the TCO. The potential cost decrease of 50 000 - 200 000 SEK during the 5-year period concludes and strengthens previous reasoning over successful partnerships in battery development and their importance for commercialization from a TCO perspective.

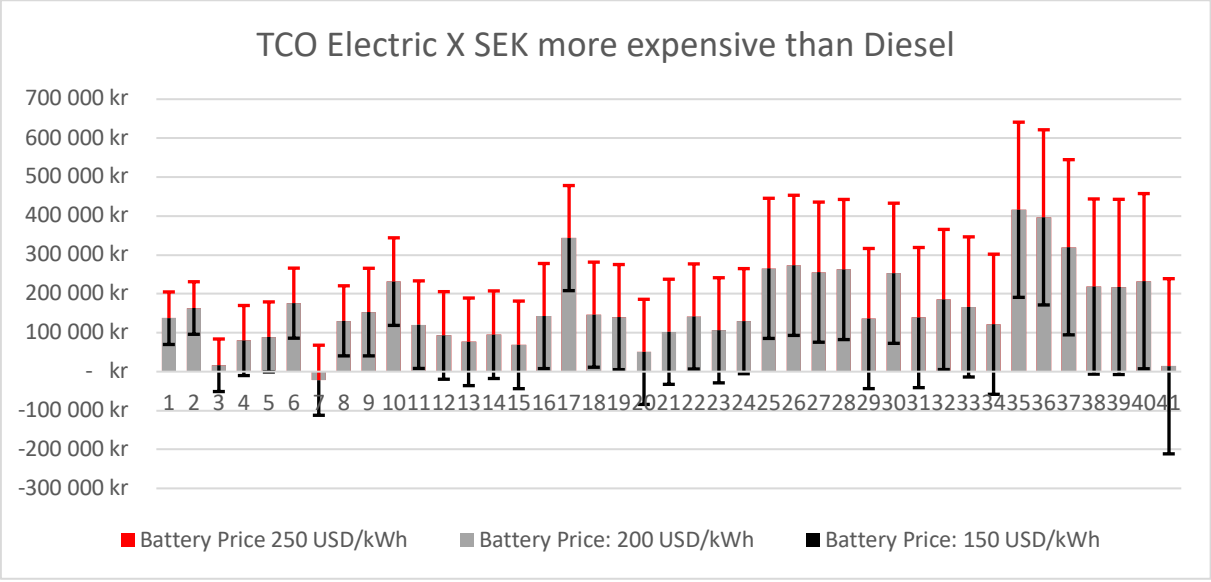

Figure 13: The TCO model's sensitiveness in regard to battery price

Since electric trucks don't cost much to operate and charge, most of the costs are upfront. Consequently, electric trucks benefit from longer payback horizons to recoup the higher investment cost. This sensitivity and impact can be seen in Figure 14 where the acceptable

depreciation time by the customer is increased from 5 to 7 years. Obviously, the factor has a significant effect by either making the gap favorable or negligible for the studied vehicles.

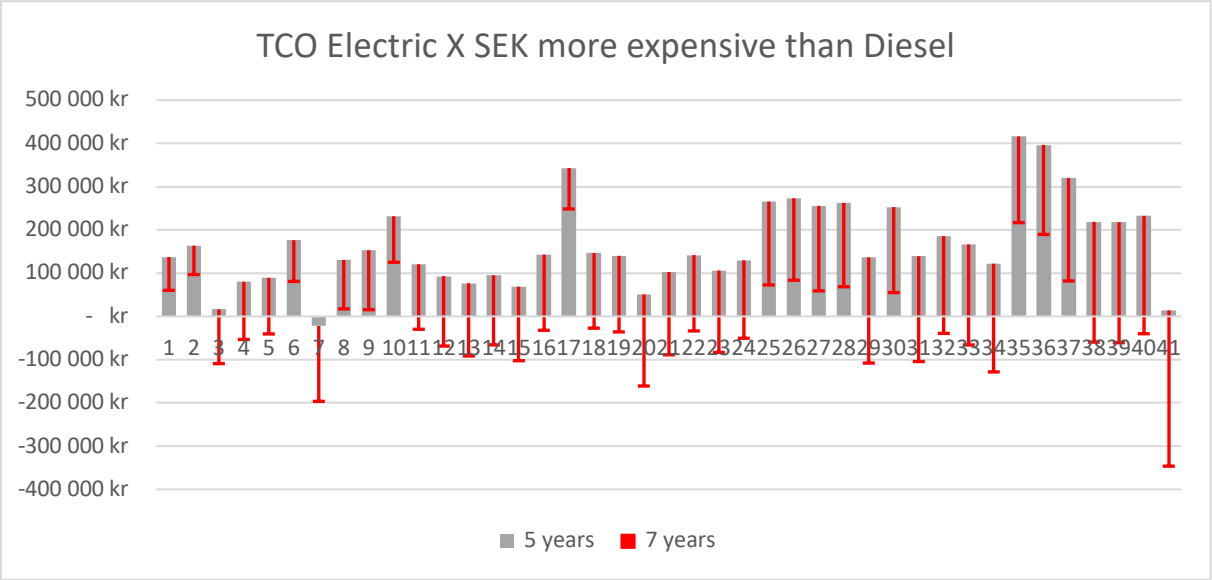

Figure 14: The TCO model's sensitiveness in regard to depreciation horizon

Since the initial cost will be higher for electric trucks than the diesel counterpart, the cost of capital increase and is therefore included in the calculations. With today's low interest rates, cost of capital doesn't compose a significant portion of the TCO, neither for a diesel nor electric truck. This is however something that may change in the future if interest rates were to rise. The impact is shown is Figure 15, yet found diminishing when compared to other the factors.

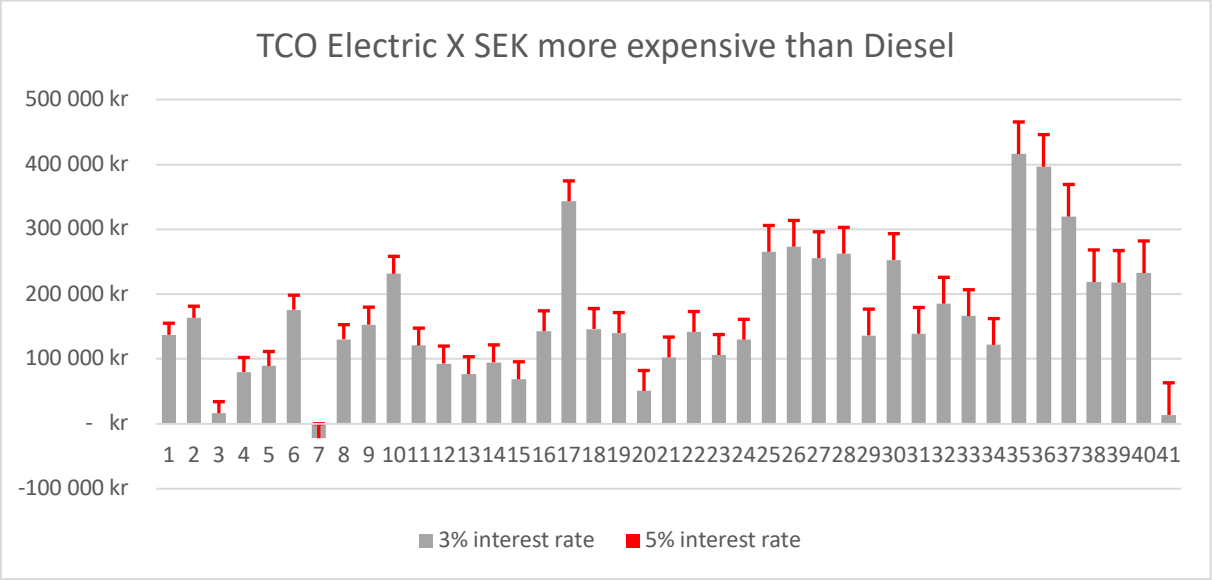

Figure 15: The TCO model's sensitiveness in regard to interest rates

Due to refuse companies preferring night charging, our calculations exclude the cost of fast charging stations which are very expensive and would overburden the TCO drastically if

included. Additionally, these chargers need to reach a high utilization to be profitable after which only needing them once a day wouldn't be enough. Night charging is on the other hand an inexpensive solution since the converter is built in the truck and the only additional cost for the customer is the installation of a three-phase outlet at the nightly parking space. Third party chargers can be a great help for situations were extra miles are needed, but initially this is not something that can't be counted on. Having access to fast charging station to either rely on or only use in special situations change the offering the customers experiences but also opens up new customer segments and markets, thus impacting the business model's value proposition.

One simplification our TCO calculations make is to disregard electric trucks' initial lack of economies of scale and instead assume the same production cost as today's diesel counterpart. The reason why this isn't accounted for is that received forecasts declare an expected equal production cost, hence making the simplification of an equal cost for the chassis. Otherwise, the conclusion is that electric trucks will have an extremely hard time to compete with diesel trucks if they can't be assembled in the same efficient way and costs as today's diesel trucks. For truck manufacturers, this may bring them to accept higher assembly costs in the beginning before they reach sufficient quantities.

Figure 16 below adds the reasoning from this subchapter and finalize the analysis by illustratively summarizing what implication the gathered data may have on existing business models. As before, circles with solid line applies for all truck manufacturers in general while dashed lines are tied to certain strategic decisions, i.e. mainly involvement in charging infrastructure and battery development as emphasized in the analysis.

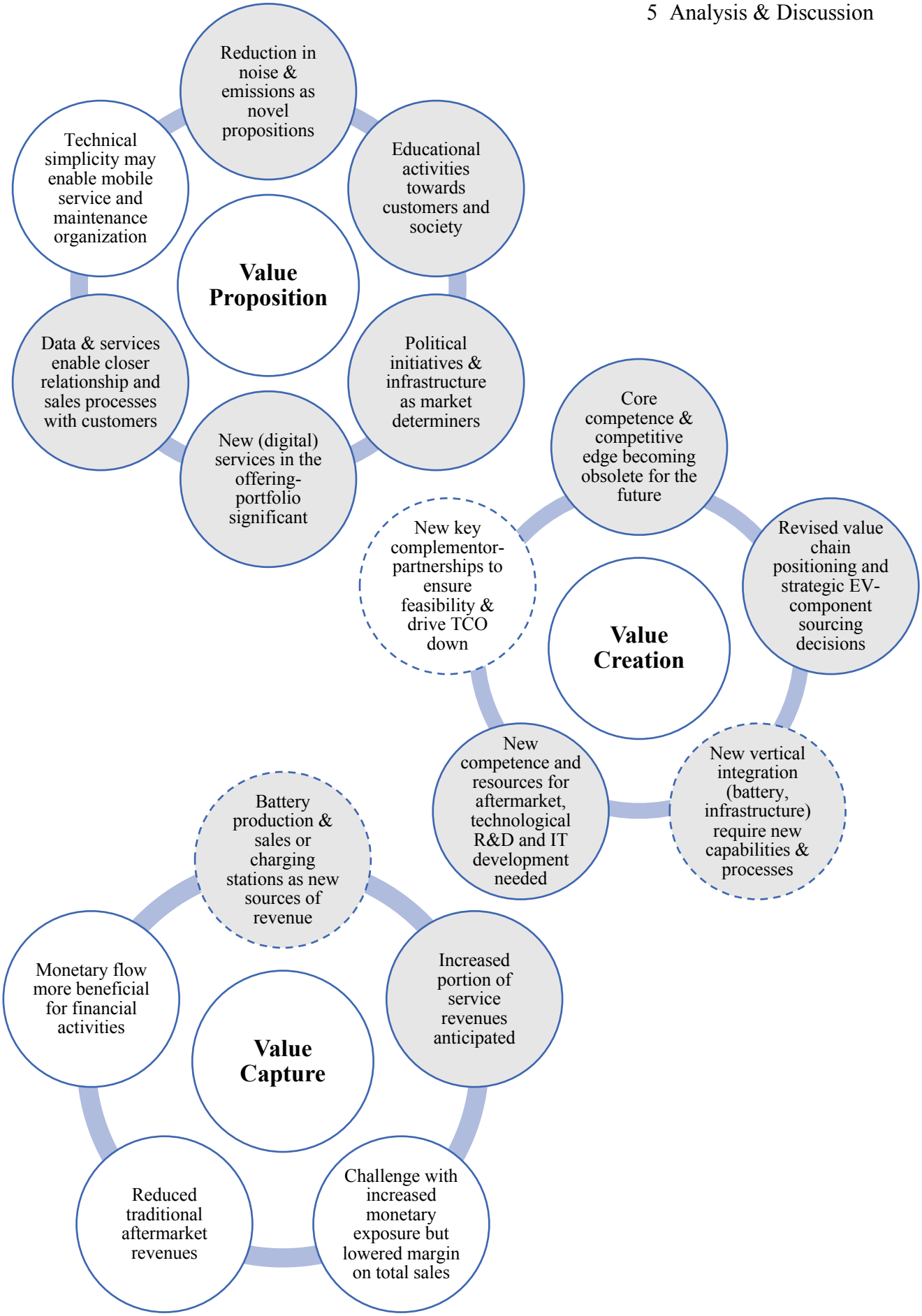

Figure 16: Summarizing illustration over emobility's impact on each value dimension in the business model framework as emphasized after investigating research question 2, 3 and 4.

6 Conclusions

Below follows a concluding chapter where results in accordance to investigated research questions and purpose is laid forward and summarized. Additionally, practical contribution, managerial implications and theoretical contribution is discussed.

6.1 A lacking need for business model innovation

This master thesis has investigated the impact a probable future electrification of the truck industry might have on incumbent truck manufacturers by taking customers' and external stakeholders' perspectives into consideration, were a special focus towards the refuse industry and (though secondary) city distribution has been taken. Upon applying the framework proposed by Clauss (2017) and analyzing empirical findings through the dimensions of value propositions, value creation and value capture, we conclude a lacking need of radical business model innovation of similar magnitude as e.g. in the case of Xerox to commercialize electric trucks for the studied fields of application. Naturally, emobility bring changes and adaptations necessary to address by incumbents. However, outwards and towards customers, few data indicate a need for business model changes of the same magnitude as the initially presented cases from Chesbrough (2007). Interviewed customers' explained ability to handle a changed monetary flow with a higher initial investment costs, willingness to adapt their operations to optimize an implementation of electric trucks and the overall enouncement of preferring a similar arrangement around their vehicles as today are arguments supporting that conclusion.

Instead, emobility appear to mainly affect the internal and supply chain-related elements of manufacturers' business models, i.e. within the value creation dimension (Clauss, 2017). New capabilities, competencies, processes, engaged partnerships and resources are all content of the business model that need to be revised. To ensure important propositions such as uptime and a functioning aftermarket, it's furthermore of high importance that adjustments are spread in the manufacturers' network to e.g. dealers or repair shops and not get caught at R&D departments. Simultaneously, the manufacturers' markets for refuse truck are that geographically apart from each other so the technology can be empirically introduced in applications locally and independent of each other. This allows for a successive adaptation of business model as the diffusion of electric trucks expand, whereas the risk of losing large sums from investing heavily in an unsettled technology as emphasized by Adner (2006) is decreased.

Massa and Tucci (2013) recognized innovations with mainly sustainability and environmental-value propositions as monetarily non-favored by most markets. Emobility possess that status today after which this study further concludes the political arena as a key player for leveraging the adoption of electric trucks through political incentives. Additionally, truck manufacturers' customer base is concluded to behave very rationally when faced with a purchasing decision where such analysis originates from customers' emphasis on TCO calculations. More of this in *Managerial implications*. The emphasis on TCO from all customers also contradict the writing of Ellram (1993) who argue that the diffusion isn't widespread.

Our initially presented key references, Stålstad and Williander (2013) and Tongur and Engwall (2014), emphasized the need of revised business models to diffuse electric vehicles. Service-based offerings where laid forward as preferable options to overcome a higher purchasing price as a barrier to adoption. Our finding of customers' emphasis on the TCO however contradict that argument and instead conclude that the purchasing price appear to be of minor importance for vehicles, intended to be used as a working tool with high utilization. Gaiardelli et al. (2014) expansion of how services take more and more place in the automotive industry is however strengthened, not least as a source of revenue, antidote towards decreased relevance and shift in power in the value chain or as a competitive differentiator.

This case study over electric trucks in Sweden further confirm the entry and conclude a high importance of servitization as interviewees at Volvo share the view of threatening profit margins and expansion possibilities as drivers of the development with Verstrepen et al. (1999). As a consequence of predicted lost revenue from service and maintenance, digital services are found to become a foundation pillar in truck manufacturers' businesses. Not only as a source of revenue but also in terms of offerings, closeness to customers and competitive advantage over competitors. Though the business models' value propositions and capturing are affected by this effect, also here is the biggest impact anticipated to figurate in-house with new competence, technology, equipment and with time a shifted organizational structure.

The frame of reference also include theory on network dependency with the essence that firms more and more operate in complex ecosystems whereas innovations' commercialization risk to become inhibited due to insufficient development of complementors (Adner, 2006; Adner & Kapoor, 2010; Mäkinen & Dedehayir, 2012). For electric trucks, such complementors mainly translates into the development and maturity of charging infrastructure whose absence historically have been explained to infringe the diffusion of electric vehicles and create barriers to adoption (Arnäs & Karlström, 2013). The investigated fields of application of this study, i.e. city distribution and refuse collection, contradict that notion. Instead, a key finding is made that these customer segment prefers to be independent from charging during the day and rather equip their trucks with enough batteries to last a full day and charge during the night. The effect on manufacturers business models is that they initially can put such issues aside and still find application areas to retrieve a proof on concept from.

6.2 Managerial implications

The transparently shared answers from interviewees in *Empirical findings* can be translated into demands which have managerial implications for truck manufacturers. Following these demands, manufacturers need to adapt and deploy a business model which ensure and enable: a full day's drive capacity on batteries, service and maintenance conveniently accessible, possibilities with all financing solutions ranging from operational lease to direct payment and lastly reliability in performance and uptime which are core propositions expected from customers. Additionally, all of this need to be provided at a sufficient TCO, i.e. equal or lower than today's costs for a diesel truck. Looking into the sensitivity analysis, longer depreciation time is highly beneficial for the TCO of electric trucks whereas convincing customers of long

term benefits is an important aspect for managers to observe. Simultaneously, it's important to align the technical life length of the expensive batteries to the calculated depreciation time, both to avoid unnecessary costs by overshooting the expectations and to be able to align battery replacements with TCO calculations. Which of these aspects to emphasize will naturally depend on which field of application the manufacturer is targeting respectively the technological maturity level by that time.

Though the technology shift is concluded not to be restricted neither constrained by the current business model design, several strategic crossroads emerge which create both opportunities and challenges that stretches over all three value dimensions in the business model framework. Though disqualified as a necessity to include in the business model for the studied application field, engagement in the establishment of charging infrastructure will most certainly become a question worth to iteratively evaluate for truck manufacturers' executives. Not least since it, beyond being a technical requirement for some application areas, could work as a mean to expand the scope of their business and to higher extent control the electrification. In terms of business model design, a management decision to buildup and operate charging infrastructure would affect the business model in all value dimensions; from the possibility to offer and ensure a full solution to customers, through entirely new processes for creating the offerings before finally realizing new sources of revenues on a recurring monetary stream. If, however the contrarious strategic decision of not engaging in the buildup is taken, manufacturers naturally become dependent on either competitors or other types of actors. The crucial business model implication to address from such a decision would be new partnerships to avoid becoming locked out from or non-configurable with emerging systems.

The study concludes political initiatives as key triggers for the adoption of electric trucks whereas activities and strategies in the business model should be designed to favor such and accelerate their formation. Managerially, this could translate in increasing the dialogue and involvement with municipalities and educate through pilot projects or empirical proof of concepts to over bridge an indicated knowledge gap among public authorities. Another managerial implication to highlight is that political influence is anticipated to initially unlock markets geographically by acting as a pioneer after which the market itself may follow when a successful proof of concept in the region exist. Managers at respective truck manufacturer therefore need to pay close attention to the surrounding world and what happens politically in their markets of interest. Announced bans for combustion vehicles and toughened climate goals in cities are suggested as examples of factors to recognize and act upon.

Emobility bring new opportunities to position the company in the value chain. The analysis concludes the possibility to expand, not only through charging as above but also by utilizing data to undertake a sales approach more alike a partner for optimizing a customer's vehicle fleet. Such downstream integration would radically reform the relationships truck manufacturers establish with its customers and transform the provided value from selling trucks from a list of specifications to ensure the most accurate truck to each individual customer. Naturally, manufacturers' strategic decisions also include whether to vertically integrate upstream and include e.g. battery development in the business. Here, manufacturers' decisions

separate where foremost Tesla Motors as a challenger develop and build their own battery factory while most other manufacturers rely on external battery suppliers. If successful, in-house development and production of batteries enable to add more margin towards the customer at the expense of a much higher technology risk. Reversely, manufacturers who exclude battery production from their business model remain dependent on external development, yet with the upside to theoretically always be able to source the best batteries in terms of performance and price.

The study concludes that incumbent truck manufacturers face an organizational challenge when their core expertise, i.e. constructing and developing the diesel powertrain, will become almost entirely obsolete as the transition to electric trucks happens. Truck companies with over 100 years of expertise and half of their R&D budget allocated to refining and further developing their diesel powertrains risk to encounter concerned individuals with different opinions and intentions to discourage the development internally. Such organizational challenges and conflicts of interests may risk delaying and obstruct necessary changes that is needed for emobility, thus necessary to managerially emphasize. Finally, managers at truck manufacturing companies need to carefully consider the balance between being fast to market and deliver a product which fulfills the customer's demand. Recurring referential to troublesome gas trucks during interviews namely indicate a tendency of short patience with a new technology not delivering what has been promised.

6.3 Final comment on contribution and suggestion for future research

Practically, this study contributes to manufacturers and truck industry in Sweden by bringing customers' and other stakeholders' perspectives into the changes electric trucks may connote. After analyzing through a business model framework, we give our conclusions and independent perception on what affect these may have on today's business models. Academically, this study contributes by adding another case of how technological shifts affects incumbent actors where our research approach distinguishes from previous by emphasizing a business model aspect. Our main conclusion is that comprehensive technological shifts which outdate incumbents' core capabilities not necessarily force radical innovation of business models, thus adding emobility in the Swedish refuse collection industry and city distribution to the body of knowledge over technology shifts as a case where todays incumbents' truck manufacturers business models actually can be sufficient for commercialization. Consequently, the notion of technological shifts as devastating for existing actors as emphasized in e.g. disruptive innovation theory is contrasted.

The study has been conducted during a period where truck manufacturers recently started to announce sale launches of electric trucks to the market. Consequently, many questions have been based on hypothetical scenarios and made it impossible for customers or stakeholders to know exactly what an electric truck brings or connote. A follow-up study which investigate if customers have deviating or changed perceptions from empirical usage after been engaged in pilot projects would be interesting to compare this thesis with. How to spread the diffusion and

take the leap from a niche market to mass market is another question worth addressing after the initial applications have been found.

A business model is large and complex construct which makes it difficult and resource demanding to deeply analyze all of its aspects thoroughly. Though the utilized business model framework of this study is only constituted of three main dimensions, its elements are so deep and intertwined that the analysis need to be held on a more aggregated level to avoid a wall of text. As a future research proposal, we therefore encourage and suggest a study over how emobility actually has affected truck manufacturers after electric trucks have been empirically applied, favorably through only one value dimension at a time to allow a more thorough investigation. Additionally, input and comparison between multiple truck manufacturers would be of interest to see which strategic actions might had most significance for success. A known limitation this study has, and that would be interesting to gain insight into, are what insights and thoughts stakeholders upstream the value chain has on emobility. Especially battery suppliers' which provide the single most important and expensive part for today's incumbent truck manufacturers. How for example the power balance in the value chain shifts due to battery suppliers' interests and intentions with emobility is thereby our final suggestion for further research.

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