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Possibilities and challenges for expanding the electric vehicle adoption

A case study of Swedish consumers' perception of electric vehicles

By

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Abstract

Electric cars are by many considered a sustainable solution to the ever-growing demand for road vehicles and fuel. The transportation sector is responsible for almost a third of the total greenhouse gas emissions globally and approximately 80% of these emissions can be attributed to road vehicles. Thus, there is an urgent need for a shift away from fossil fuels in the sector. While the consumer interest for electric cars has certainly increased in the past few years, the shift to electric vehicles is not occurring fast enough. This thesis deals with the process of consumer adoption of new technologies and aims to investigate the possibilities and challenges for expanding the consumer adoption of electric vehicles in Sweden, mainly through the lens of the diffusion of innovation-theory. The findings of this qualitative case study of Swedish consumers within the automotive sector suggest that the main possibilities for expanding the electric vehicle adoption are the consumers´ generally positive perception of beneficial environmental effects, relatively cheaper fuel and social status, related to electric vehicles. The main challenges involve negative perceptions of the driving range, price, infrastructure, complexity, limited opportunities to test and observe the electric car and intangible results. This study employs a semi-structured interview technique, and analyses the perspectives of different consumer groups with different consumer behavior and above all, different tendencies to adopt to new innovations, ideas or technologies. The intention is, by doing so, to achieve a sufficient representation of the consumers in the automotive sector within the limitations of the thesis. One of the most important conclusions of the findings is that in order to exploit the possibilities distinguished in this study, it is vital that the complementaries to the innovation (electric car), such as the related infrastructure, develop at a similar rate as the actual innovation in order to prevent bottleneck effects. If this development fails, the rate of adoption will likely stagnate. Furthermore, the findings suggest that there is a substantial lack of sufficient information about electric vehicles among mainstream consumers, causing uncertainty among these individuals. The policy implications of the findings are thus related to a need for better distribution of information and decisions for preventing bottleneck effects caused by the underdeveloped infrastructure surrounding electric vehicles.

Keywords: electric vehicle, consumer adoption, sustainability, diffusion of innovation, ICE vehicle.

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Abbreviations

EV(s) Electric vehicle(s)
ICE(s) Internal combustion engine vehicle(s)
PHEV(s) Plug in hybrid electric vehicle(s)
NEDC New European driving cycle
WLTP Worldwide harmonized light duty vehicles test procedure

1. Introduction

Electric vehicles are by many considered a sustainable solution to the ever-growing demand for more vehicles, and more fuel (Milev et al., 2021). The transportation sector is responsible for around 30% of the total greenhouse gas emissions globally (EPA, 2019) and approximately 80% of these emissions can be attributed to road vehicles (Statista, 2019). Thus, there is an urgent need for a shift away from fossil fuels in the sector. While the demand for electric cars has certainly increased in the past few years, the shift towards more sustainable practices is not fast enough. This thesis will deal with the process of consumer adoption of new technologies in order to investigate the possibilities and challenges for an expansion of the electric vehicle adoption.

With regards to the challenge of achieving the sustainable development goals, numerous examples of literature have recently been highlighting the importance of sustainability transitions (Scoones et al., 2018) and the diffusion of sustainable innovations (Clausen and Fitcher, 2016). In the past decades, increased focus has been directed to the environmental and social effects of the progressive development resulting from modernization processes of the world (Grin et al., 2010). As a response to the increasing social and environmental threat posed by the current unsustainable consumption and production patterns, research on sustainable innovations and how they spread and cause changes in socio-technical systems, have achieved increased attention (Hölscher et al., 2018). Innovations are diffused through an adoption process where different elements of the sociotechnical system interact and where the decision of adoption depends on the consumers' perception of and relation to the innovation. When an innovation reaches critical mass, namely when a sufficient number of adopters in a social system has accepted the innovation so that the rate of adoption becomes self-sustaining and creates further growth, the innovation can be defined as diffused (Rogers, 1962; 2003). Scholars define consumer adoption of an innovation as a behavioral response comprising of the purchase and use of the innovation (i.e. Schuitema et al., 2013; Huijts et al., 2012; Jansson et al., 2010). While research on diffusion of innovation has been done for several decades, the spread of sustainable innovations, its drivers and impacts, is a research area that has attracted increased scrutiny in just the past few years. When a sustainable innovation is diffused throughout a social system, a sustainability transition can be achieved. (Foxon and Pearson, 2008). The concept of sustainability transitions is defined as a drastic transformation towards a more sustainable society and aims to explain how more sustainable consumption and production patterns can be achieved through shifts in socio-technical regimes. Socio-technical regimes are based on the informal and formal institutions such as regulations, policies, norms and values that have developed along with specific technologies and turned into practices and routines. The regime represents the deeply rooted construction of the socio-technical system and represents the means-end coherence in a given sector. The aim of the research area of socio-technical regimes is to analyze the elements and consequences that the formal and informal institutions have on transition dynamics (Rip and Kemp, 1998; Geels 2002; Geels and Schot 2007).

When transitions occur, a shift from one socio-technical regime to a different one happens, and in the more specific case of sustainability transitions, the current regime transforms towards a more sustainable one (Fuenfschilling and Binz, 2018).

While many aspects are involved in the process of sustainability transitions, various researchers have stressed the importance of social factors and consumer behavior (Peatti, 2010; Lebel and Lorek, 2008). The rate of adoption of a sustainable innovation is vital for the possibilities for regime change. The consumer's perception of the innovation and the surrounding system has thus been discussed as an important factor for adoption and diffusion of sustainable innovations and consequently for sustainability transitions (Rezvani et al., 2015). However, it has been pointed out that this area needs more attention in order to increase the understanding of the impact of consumption behavior and the consumers' perception and experiences, on the diffusion of sustainable innovations (Niinimäki and Hassi, 2011).

1.2 The automotive industry

The automotive industry is one of the most polluting industries in the world and is the cause of many substantial climate issues. The unsustainable consumption and production patterns of the sector and the problem they cause, require drastic measures and many researchers have stressed the need for a transition in the industry towards more sustainable practices (Jansson et al., 2018). A mixture of potentially significant changes in technology, commercial structures, and social practices is currently entering the automobility system. These changes have the potential to combine together and lead to a substantial shift in the manner in which society fuels, owns, and makes use of cars. The possible emergence of a new socio-technical regime in the automotive sector still needs further research (Morton et al., 2017).

Although the automotive sector has experienced a century of unconquerable growth, the industry is currently facing large issues as the global expansion of private vehicle usage is causing growing climate problems and damage to the planet. The rise of the automotive industry and the emergence of the automobile society are largely results of cultural, financial and political factors, and the strong linkages, not only between elements within the industry, but also between elements of the automotive industry and other sectors, namely development blocks and complementaries (Dahmén (1950; 1970; 1988; Schön, 1990, 1991, 1994, 2000 a, b; Kander et al., 2013). These very deeply rooted and strongly connected linkages have over the past century led to mass production of vehicles and extensive economic growth, as well as improved living standards for many (Edsforth, 1987; Cohen, 2003; McCarthy, 2007). Nevertheless, the climate damage caused by the unsustainable patterns in the sector creates a need for drastic changes in the current socio-technical regime. Fossil fuel combustion accounts for more than 80 % of the total anthropogenic greenhouse

gas emissions worldwide (Jansson et al., 2010). The transportation sector is the single largest generator of greenhouse gas emissions with a share of approximately 30 % of the total emissions globally, which is more than twice the share of 1970 (EPA, 2019). Around 80 % of this increase can be attributed to road vehicles (Statista, 2019).

As a response to the growing pressure of climate issues, the focus on sustainability policies has increased in order to reduce the pollution caused by the industry, and some niche innovations have started to emerge on the market. Several manufacturers have begun to produce alternatives to vehicles driven by fossil fuel, such as flexible fuel vehicles or cars driven by biogas or electricity. Other innovative solutions such as car sharing have also been growing on the market. This study will be focused on the innovation of electric cars as the market has seen a rapid advancement and expansion of electricity driven vehicles in the past decade, and they are often discussed as a possible solution to modern pollution issues (Schmid, 2017). However, problems related to infrastructure, product prices, and political and economic issues, may hinder an upscaling of electric cars and enacting transformations of the current socio-technical system (Lee and Clark, 2018). Sweden is currently ranked as one of the top ten most lucrative markets for plug-in vehicles (BIL Sweden, 2021). In 2019, more than 5% of all battery electric cars and approximately 8% of all plug-in hybrid electric vehicles in Europe were registered in Sweden (Statista, 2019). The rapid national growth of electric vehicles makes Sweden an interesting case to study in terms of diffusion of sustainable innovations.

1.3 Research question

Some researchers argue that the current advancement of electric vehicles may be the start of a transition towards sustainability in the automotive industry (Jansson et al., 2017). However, diffusion of innovation and subsequent shifts in socio-technical regimes are complex and the question is how the automotive industry successfully can shift from one socio-technical regime to a more sustainable one through a diffusion of electric vehicles (Vaz et al., 2017). In spite of the purported environmental benefits, and the increasing number of sold electric vehicles in Sweden, the share of electric vehicles in the total number of vehicles sold internationally is still small. In 2020, the electric vehicle market share was only just above 5 percent of the total new passenger car registrations in the EU (Statista, 2021). One perspective on such modest adoption figures is that the mass acceptance of electric vehicles (EVs) is mainly reliant on consumers' perception of them. Consequently, in order to promote EV adoption, it is important to understand how consumers perceive EVs and what the possible drivers for and barriers against consumer adoption of electric cars are. In other words, we need to know what factors influence consumers' intentions to purchase EVs. Against this knowledge, we can identify the opportunities and challenges for an expanded adoption of electric vehicles (Schuitema et al., 2013). Thus, the question that will be the basis of this thesis is:

What are the main possibilities and challenges for expanding the adoption of electric vehicles in Sweden?

1.4 Research aim and contribution

The aim of this study is to contribute to the understanding of the possibilities and challenges for achieving an expanded consumer adoption of electric vehicles. This thesis will contribute with a qualitative view on the experiences of different consumer groups within the social system, which will hopefully provide a sufficient tool to get a credible and trustworthy picture of the prospects of an expanded adoption and diffusion of electric vehicles and thus, how a sustainability transition may come about.

1.5 Outline of the thesis

The remainder of the thesis is organized as follows. Chapter two consists of a presentation of different theoretical frameworks and previous research that is considered relevant for this study. This entails descriptions of sustainability transitions (2.1), diffusion of innovation (2.2), development blocks (2.3) and more specific literature on electric vehicles (2.4). The third chapter presents the qualitative research design, approach and the methodological procedure for data collection through interviews, and analysis. Chapter four presents the empirical analysis of different consumers' perception of electric vehicles and what the possibilities and challenges for achieving a more widespread consumer adoption of electric vehicles in Sweden are. Following this, chapter five presents a discussion and concluding remarks obtained from the analysis of the data, and some implications of the findings as well as suggestions for further research are discussed.

2. Literature review

In order to provide a broad introduction to how industries can shift towards more sustainable patterns through the spread of new innovations, the theory of sustainability transitions will be described. An explanation of what the process of sustainability transitions looks like and how they come about, will be presented using the multilevel perspective (Rip and Kemp, 1998; Geels, 2002; Geels and Schot, 2007). Following this, the diffusion of innovation-framework by Rogers (1962; 2003) will be described in order to increase the understanding of consumers' attitudes towards new ideas and how new innovations are adopted and diffused. A short explanation of Erik Dahmen's (1950; 1970; 1988) concept of development blocks, will further be presented. Additionally, previous research on electric vehicles and the current status of adoption will be presented as a background of what the literature has found so far within the topic.

2.1 Sustainability transitions

As a response to the current unsustainable practices and financial interests, various researchers stress the need for changes in the way production and consumption is carried out. Several different approaches to analyzing the phenomenon have been suggested. Some authors point to the need for drastic structural shifts in the production and consumption systems. Others highlight the benefits of accelerating incremental change, and some argue that change must emerge from below through grassroots innovations, movements and networks, which will gradually construct wider change. The systematic approach of analyzing transitions has in the last couple of decades received large recognition and many sophisticated case studies executed through the approach has led to great implications for understanding transitions towards sustainability (Markard, 2012). The multilevel perspective (MLP) is a prominent theoretical framework for analysis of systematic transitions. The multilevel perspective was developed by Rip and Kemp (1998), and further evolved by Geels (2002) and Geels and Schot (2007). The framework has since its emergence been widely recognized and used in research of sustainability transitions. The multilevel perspective describes transitions as a process emerging through interaction processes within and among three analytical levels: the socio-technical landscape, socio-technical regimes and technological niches (Rip and Kemp, 1998; Geels, 2002; Geels 2007).

The socio-technical landscape refers to external aspects and trends like macro-economic trends, crises and wars, climate change, pandemics, demographic change. The socio-technical landscape rarely shifts in the short term, but it can constitute a spring of pressure for regime change or create opportunities for niche developments. The inertly moving developments on the landscape level are illustrated by the thick, long arrows in figure 1. *The socio-technical regime* is defined as the deeply rooted incumbent structure of the socio-technical system. The socio-technical regime contains

actors and social groups as well as the networks between them, formal and informal rules maintained by the actors, and the technical and material aspects related to the regime (Rip and Kemp, 1998; Geels, 2002; Geels and Schot, 2007). Socio-technical regimes are further characterized by their purpose, self-determination, consistency and stability. Regimes rarely change and reconfiguration tends to happen slowly when it occurs (Holtz et al., 2008). The stable nature of socio-technical regimes is based on linkages between heterogeneous factors, which are in turn developed by social groups and their reproduction of these factors and the linkages between these groups. For instance, the values, culture and symbolic signs surrounding vehicles are created and maintained through interactions between consumers, media and other societal groups, and usage practices, transportation behavior and patterns are created by different consumer groups in their daily usage of vehicles. Regulations and infrastructure are developed by policy makers. The structure of the market and industry is developed by manufacturers and suppliers and their strategies, and engineers and manufacturers create the technical knowledge incorporated in vehicles. All of these different elements are linked and aligned in a structured configuration and are according to Nelson and Winter (1982), the outcome of organization and cognitive routines by the actors and organizations involved. Rip and Kemp (1998) further define this phenomenon as the sociological "rules of the game". Geels 2002 distinguishes seven different dimensions in the socio-technical regime which interact in incremental processes; technology, user practices and application domains (markets), symbolic meaning of technology, infrastructure, industry structure, policy and techno-scientific knowledge. While there are interrelations of the different dimensions, the dimensions in themselves also contain internal dynamics, which may cause tensions that could weaken the interlinkages. This tension is illustrated by the shorter arrows in figure 1. *Technological niches* are described as "incubation rooms" where novelties emerge from the micro-level. These novelties are initially unstable in their nature and can in the early stages be viewed as low performing socio-technical configurations (Rip and Kemp, 1998; Geels 2002; Geels and Schot, 2007). The niche innovations build internal momentum and create opportunities for change. The radical innovations on the niche level are initially moving in different directions, as a presiding and stable design has not yet been established. This leads to a large variety of socio-technical innovation which is represented by the small arrows in figure 1. If the niche innovations can be stabilized into a dominant design, the innovation can be scaled up and cause shifts in the sociotechnical regime. This is illustrated by the growing arrows, piercing the regime level in the figure. According to the multilevel perspective, transitions emerge through an interaction process between the three levels: niche innovations, landscape pressure and the socio-technical regime. The landscape pressure destabilizes the regime which opens up for niche innovations to enter and shift the socio-technical regime towards a new one. According to the framework, the processes of the three levels must be aligned in order for a transition to come about. (Geels, 2002; Geels and Schot, 2007).

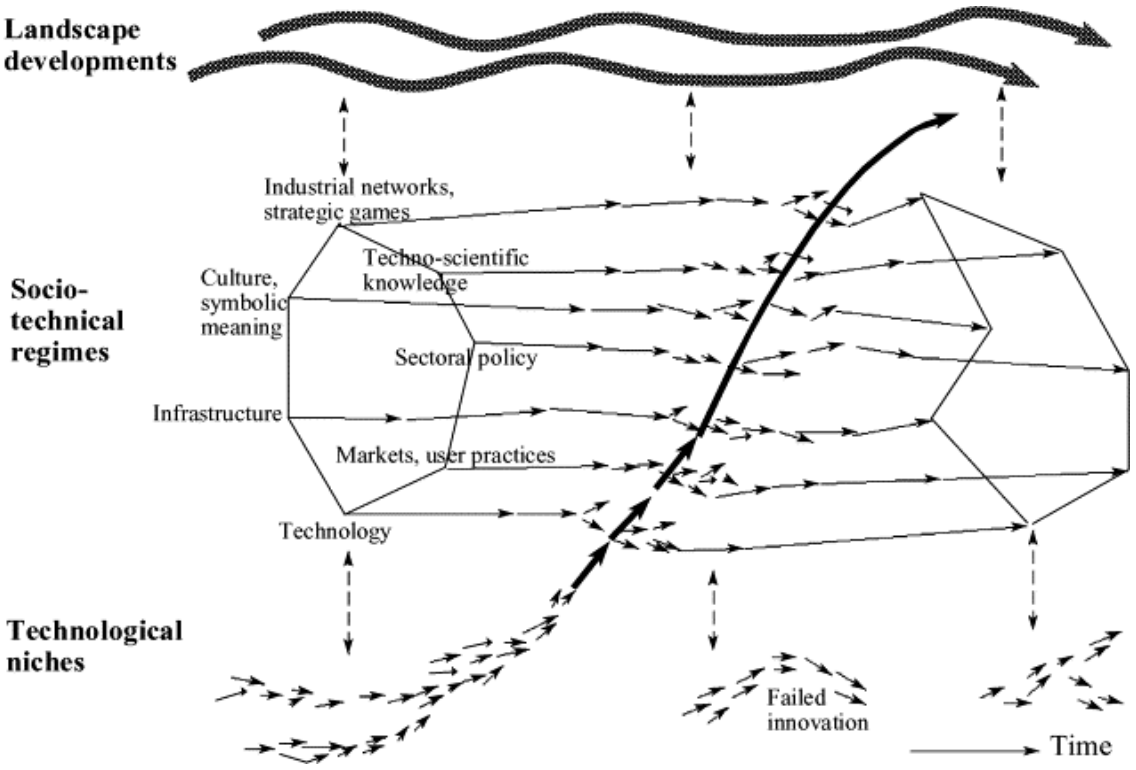

Figure 1. Multi-level perspective on transitions (from Geels, 2002, p. 1263).

2.2 Diffusion of innovation

A vital part of the process of sustainability transitions is the diffusion of a sustainable innovation. Diffusion of innovation is a framework developed by Rogers (1962; 2003) and it aims at explaining how a product or an idea can gain momentum and spread through a specific social system or population over time, with the end result that people in the social system adapt to the new product, idea or behavior. Getting a new innovation adopted, even when it has clear advantages, can be a lengthy procedure from the time it is made available to consumers to the time when it is widely diffused. According to Rogers (1962; 2003), the key to adoption is that individuals perceive the new product, idea or behavior as innovative. Essentially, the framework explains diffusion of an innovation as a process by which an innovation is communicated through communication channels over time within a social system. The four elements; innovation, communication channels, time and the social system will be described below.

Innovation

Rogers (1962; 2003) defines an innovation as an idea, object or practice that an individual or other unit of adoption perceives as new. It does not matter as much if the innovation is objectively new, as the individual's perception of whether it is new or not. If the individual sees the idea as new, it is an innovation. The novelty of an innovation can be communicated in terms of persuasion, knowledge or decision to adopt. The stages by which a person adopts an innovation, and whereby diffusion is accomplished, include awareness of the need for an innovation, decision to adopt (or reject) the innovation, initial use of the innovation to test it, and continued use of the innovation. Rogers (1962, 2003) recognizes five categories of factors that influence the adoption decision, namely relative advantage, compatibility, complexity, trialability and observability. These factors are explained below:

(1) Relative Advantage - The degree to which an innovation is seen as better than the idea, program, or product it replaces. The degree of relative advantage can be measured in monetary terms, but can also be measured by social prestige, convenience or satisfaction. Whether or not an innovation has a great deal of objective advantage does not matter so much, but rather the individual's perception of the innovation as advantageous. The larger the perceived relative advantage of an innovation, the more rapid rate of diffusion of it.

(2) Compatibility - How consistent the innovation is with the values, experiences, and needs of the potential adopters. An innovation or idea that is not in line with the values and norms of a social system will not be adopted as rapidly as a novelty that is compatible. An adoption of an innovation that is incompatible with the social system often requires an adoption of a new value system first, which is a very time-consuming process.

(3) Complexity - How difficult the innovation is to understand and/or use. Some innovations are easily understood by the majority of the members in a social system, but some are more complex and harder to comprehend or use. An innovation that is hard to understand or use will result in a slower adoption of it, and innovations that do not require adopters to develop new skills and knowledge are adopted more rapidly.

(4) Trialability - The extent to which the innovation can be tested or experimented with before a commitment to adopt is made. If new innovations can be tried on the installment plan tend to be adopted more rapidly that novelties that are divisible. An innovation or new idea that is triable will reduce the uncertainty for consumers that are considering adopting it as they can gain knowledge by trying the novelty.

(5) Observability - The extent to which the innovation provides tangible results, and results that are observable to others. The more visible the results of an innovation are to individuals, the more likely it is that they will adopt the innovation. Visibility often causes discussions within the social systems and friends or neighbors tend to ask for information and learn further about the innovation. For example, it is quite common that clusters appear around visible innovations such as entire neighborhoods adopting solar panels. This shows the importance of observability when it comes to new innovations.

Communication channels

Diffusion can be viewed as a communication process where the message of the communication is related to a new idea. The exchange of information between individuals is essential to the diffusion process. The exchange (in its most elementary form) occurs with the involvement of an innovation, an individual that possesses knowledge or experience of the innovation, an individual that does not possess knowledge or experience of it, and a communication channel by which the two individuals are connected. The nature of this information exchange and the relationship between the two parts, decides the conditions under which an innovation will or will not be transferred from one part to the other. It also determines the effects of such an innovation transfer. Media channels are commonly the quickest way to spread information about a new innovation to potential adopters, as they enable a small number of people that possess knowledge of the innovation to reach a large audience. However, interpersonal channels can be far more persuasive. Interpersonal channels are based on a face to face interaction between two or more individuals, but interpersonal interaction can also involve interactive communication via internet channels. According to Rogers (1962; 2003), most individuals do not base their evaluation on scientific studies on the effects of the new innovation. While these types of studies can be relevant to the very first people who adopt an innovation, most individuals mainly rely on subjective evaluations of the innovation that are communicated to them by individuals similar to themselves that have already adopted the innovation. Thus, it can be said that diffusion is a social process, which is dependent on the imitation by potential adopters of the peers that have already adopted an innovation.

Time

The adoption of a new innovation does not occur simultaneously in a social system, but it is rather a process where different individuals are more or less likely to accept and adapt to the innovation. The time aspect is involved in the diffusion process from when an individual first obtains knowledge of an innovation to its adoption or rejection of it. Time is further a factor when it comes to the innovativeness of an individual compared to other members of the system, which means how relatively early or late the innovation is adopted. The diffusion time is also related to the rate of adoption in a system which is often measured by the number of individuals in a system who adopt the innovation during a given time. When analyzing the process of diffusion of a novelty, it is important to understand the characteristics of the target population that will either help or hinder the adoption and spread of the product, idea or behavior. Rogers (1962; 2003) identifies five established categories of adopters. The majority of people tend to fall into the two middle categories. However, Rogers (1962; 2003) argues that it is vital to understand the different characteristics of the groups as they give different implications for strategy formation for appealing to the different groups and achieving diffusion.

(1) *Innovators:* These are people who want to be the first to try the innovation. They are venturesome and interested in new ideas. These people are very willing to take risks and are often the first to develop new ideas. Very little, if anything, needs to be done to appeal to this population.
(2) *Early Adopters*: These are people who represent opinion leaders. They enjoy leadership roles and embrace opportunities of change. They are already aware of the need to change and thus very comfortable in adopting new ideas. Strategies to appeal to this population include how-to manuals and information sheets on implementation. They do not need information to convince them to change.
(3) *Early Majority:* These people are rarely leaders, but they do adopt new ideas before the average person. That said, they typically need to see evidence that the innovation works before they are willing to adopt it. Strategies to appeal to this population include success stories and evidence of the innovation's effectiveness.
(4) *Late Majority:* These people are skeptical of change and will only adopt an innovation after it has been tried by the majority. Strategies to appeal to this population include information on how many other people have tried the innovation and have adopted it successfully.
(5) *Laggards:* These people are bound by tradition and very conservative. They are very skeptical of change and are the hardest group to bring on board. Strategies to appeal to this population include statistics, fear appeals, and pressure from people in the other adopter groups.

According to Rogers (1962; 2003), the rate of adoption can be viewed as an S-shaped curve given that the number of individuals who adopt to a new idea is plotted on a cumulative frequency basis over time. Initially, only a small number of people (the innovators) adopt the innovation in each time span. As more and more people begin to adopt the innovation in each succeeding time, the diffusion curve starts to rise. After a while, the trajectory of the adoption rate will begin to flatten out as there will be fewer individuals left who have yet to adopt the new innovation. Finally, the S-shaped curve will reach its asymptote and the diffusion process will be completed. The reverse to the adoption curve is the learning curve or price curve, which has a mirror-like S-shape. As innovations spread there are learning and economies of scale that lowers the price, and naturally enforces the adoption (Bass, 1980).

The social system

Rogers (1962: 2003) describes a social system as a set of members that are involved in a common situation of problem solving to reach a common goal. The members of the social system can be individuals, organizations, subsystems or informal groups. A social system involves a clear structure which can be defined as a patterned order of the units in the system. This structure provides a stability and regularity to the behavior of the units within the social system. One of the

aspects of this structure is the norms that determine the behavioral patterns of the members within the system. The structure of the social system can either fertilize or hinder the diffusion of a new idea. Rogers (1962; 2003) points to three main forms of innovation decisions that can come about in a social system. Firstly, optional innovation decisions happen when an individual chooses to adopt or reject an innovation without the influence of other members' decisions. Secondly, collective innovation decisions are based on the choice to adopt or reject an innovation through an agreement among the systems members. Thirdly, authority innovation decisions occur when relatively few individuals who possess status, power or expertise make the decision to adopt or reject an innovation.

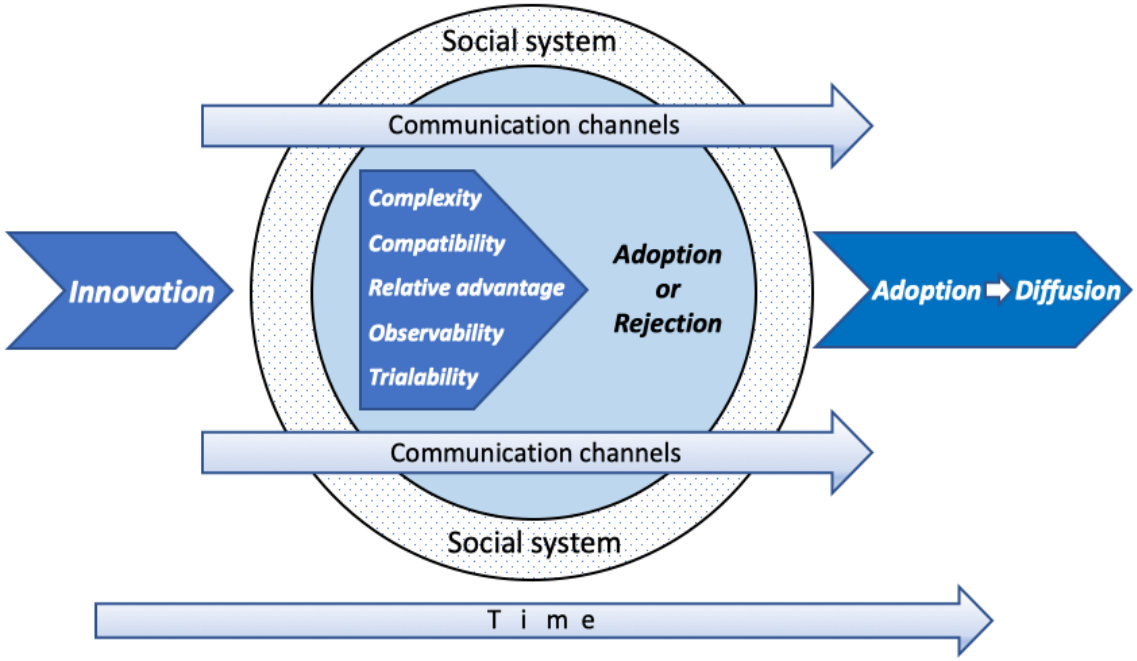

Figure 2: diffusion of innovation (own construction based on the concepts in Rogers, 1962; 2003).

2.3 Development blocks and bottlenecks

The concept of development blocks formulated by Erik Dahmén (1950; 1970; 1988) infers that innovation nourishes entrepreneurial activity in blocks of complementary activities, structuring the Schumpeterian process of creative destruction. Consequently, innovations and their complementaries are the two primary components of development blocks. New innovations result in development of new complementaries as they create new linkages between certain functions or properties within the process of production or between the production process and infrastructure

and institutions. However, the emergence of complementaries takes time, which creates a process where bottlenecks and imbalances surface. These bottlenecks and imbalances may in themselves stimulate future investments which may create an acceleration of the structural change and transformation of the economy or industry. As the complementaries catch up and finally are completed, the elements with the development block simultaneously increase the growth and productivity. Dahmen's (1950; 1970; 1988) theory declares that growth is indeed a dynamic and irregular process that entails a conflict between old and new combinations of innovations and complementaries, which escalates in periods of creative destruction. In a further elaboration of development blocks and transformation pressure by Lennart Schön (1990,1991,1994,2000a, b), it is stated that the quality of complementaries determines the robustness of the structures created by the development blocks. Lennart Schön (1990,1991,1994,2000a, b) further elaborates that new innovations and technologies are especially distinct in the transportation field in their capacity to build development blocks with a very large societal impact. Electricity has long been a central part of the Swedish industrial advancement and electrification can be seen as a development block with substantial potentials and complementaries. However, the electrification of industry has historically proven to require great investments in the generation and distribution of electrical power and the structure surrounding the industry (Enflo et al., 2006).

The IT-revolution has resulted in many economists shifting their attention to the occurrence of radical innovations and technological shifts, which has led to the development of the concept of general purpose technologies, (GPTs) (Helpman 1998; Bresnahan et al. 1999). The concept of development blocks captures the main dynamics of the process that occurs when a general purpose technology develops and stretches across generations. The basic innovation emerges within different development blocks over time on its path to becoming a GPT. Fulfilling a development block with radically new complementarities is a time-consuming investment process. In the period of breakthrough, which is characterized by a structural transformation, the positive productivity effects created by the innovation or new technology, is often hindered by bottlenecks in the economy when complementaries are insufficient (Schön 1991). In the case of the emerging development block around electric vehicles, there are bottlenecks in the sense of insufficient infrastructure and capacity of batteries. We will come back to these aspects in the analysis of the case study.

2.4 Electric vehicles

Plug-in electric vehicles have the capacity to cause considerably less carbon dioxide emissions than internal combustion engine (ICE) cars, and thus an increased use of electric vehicles can potentially lead to significantly reduced emissions accounted for by the automotive industry without cutting back the use of personal vehicles. However, the potential of reaching a diffusion of electric vehicles requires an increased understanding of the consumer responses to the usage of

electric cars or why consumers opt out of using electric vehicles. Governmental investment, incentives and regulation have been developed in order to increase the usage of electric vehicles and plug in hybrids (PHEV) in Sweden. The government has initiated the "climate bonus", which means that cars and light trucks/buses newly registered from 1 July 2018 having a CO_2 emission of maximum 60g/km (NEDC value)[1] received a bonus of up to SEK 60,000, depending on the CO_2 emission. From 1 January 2020 the CO_2 limit for new registrations to receive a climate bonus has been increased to 70g/km measured according to WLTP[2]. For electrical vehicles with zero CO_2 emission the bonus is SEK 60,000 and plug-in hybrid electric vehicles (PHEV) with CO_2-emission of 70g/km receive a bonus of SEK 10,020. The climate bonus must not exceed 25% of the new car price. In Sweden, where cars are not subject to registration taxes, the application of this approach would favor ICE over electric cars, given their comparatively lower purchase price. However, the taxation for company owned EVs and PHEVs has been reduced. The Swedish legislation allows for reducing the value of the benefit represented by the private use of company cars if they are electric, and therefore reduces the amount of income taxes that needs to be paid on it. The government has further committed to allocating SEK 90 million annually to support home chargers with up to 50% or SEK 10 000 for hardware and installation costs Additionally, plans to expand the innovative technology behind the world's first electric charging road to other parts of the country are currently in place (eafo.eu).

The governmental measures seem to have had some impact on the usage of EVs. The number of used EVs have increased in the past decade from only 157 electric cars registered in 2009, to more than 30.000 in 2019. Additionally, the amount nearly doubled from 2018 to 2019. Moreover, Sweden was in third place of European countries with the largest market share of newly registered electric vehicles. 5.1 % of all EVs and approximately 8 % of all PHEVs in Europe were registered in Sweden. While these numbers may seem promising, the Swedish governmental target of becoming carbon neutral in 2045 will require 2.5 million EVs and PHEVs by the end of the next decade. This will call for a major shift in consumers' attitude towards everyday transportation methods (Statista, 2021). Many researchers have attempted to investigate the potential of a transition to plug-in vehicle usage, but there is still no real consensus on the consumer attitudes towards EVs. Various examples of previous research on consumers' attitudes towards alternatively fueled cars have implied an underwhelming level of interest tainted by utility-based concerns regarding vehicle range, ranging times and maximum vehicle speed. Other factors such as cost, environmental beliefs and durability have also been discussed when analyzing the forecast of a

[1] NEDC stands for "new European driving cycle" and refers to fuel consumption and exhaust emissions measurements carried out on a test rig (Volswagen.com).
[2] WLTP stands for "worldwide harmonized light duty vehicles test procedure" and refers to a uniform fuel consumption and exhaust emissions test procedure for different types of powertrain (gasoline, diesel, natural gas and electric) (Volswagen.com).

transition to plug in EVs (Lieven et al., 2011; Musti and Kockelman, 2011). These studies, however, have been based on respondents with little knowledge about electric vehicles, which may mean that the responses are affected by uncertainty and unfamiliarity (Altmann et al., 2003; Axsen and Kurani, 2009; Kurani et al., 1996). Others have found that the willingness to adopt EVs is driven by the consumer's desire to gain enjoyment or minimize negative effects or feelings in the driving experience (Gardner and Abraham, 2007; Mann and Abraham, 2006; Steg, 2005). Some studies have instead investigated attitudes towards EVs by collecting evaluations of first hand experiences of EVs, or using participants that have already made the decision to purchase an electric car (Kurani et al., 2008; Heffner et al., 2005; Heffner et al., 2007; Kurani et al., 2008). However, these studies focus on the very early adopters or innovators of the market which decreases the transferability to the greater mass of the consumers (Kurani et al., 2008; Rogers, 2003). For instance, some findings have shown that early adopters and innovators express a much larger commitment to environmental effects of vehicles (Kurani et al., 2008; Jansson et al., 2010), while more mainstream consumers consider other factors more when making everyday mobility decisions (Gardner and Abraham, 2007). Some studies have considered a selection of more mainstream consumers. Rowe et al., (2012) investigates the responses to plug-in electric vehicles by mainstream consumers in the UK. The findings suggest that the barriers to mainstream diffusion of current generation plug-in electric vehicles include that many mainstream consumers prioritize personal needs for mobility over environmental benefits. Furthermore, concerns regarding the social desirability of electric vehicle usage and the fear that the rapid technological and infrastructural development will result in current models of electric vehicles quickly getting obsolete. Six major categories of responses to electric vehicles were identified in the analysis: cost minimization, vehicle confidence, vehicle adoption demands, environmental beliefs, impression management, and the general perception of electric cars as a “work in progress”. While some studies have already looked into consumer attitudes in relation to EV adoption, few examples of literature include a selection of participants with both users and non-users of Evs. This study will do so for the case of Sweden.

3. Methodology and data

In this chapter, the appropriate research approach, design and methodology to answer the research question will be identified. First, the research approach (3.1) and design (3.2) of the study will be described. Thereafter, the data collection (3.3) will be explained and details of the selection of participants and interview methods will be provided. Moreover, the data analysis (3.4) will be identified. Finally, the credibility and trustworthyness (3.5) and limitations (3.6) of the study will be discussed in order to provide some objectivity and transparency related to how the research and data analysis is performed.

3.1 Research approach

This thesis aims to identify the possibilities for, as well as challenges in, achieving a diffusion of electric vehicles through consumer adoption, and consequently a regime shift in the automotive sector. As the intention is to contribute with additional knowledge about the consumers' perception of electric vehicles and the possibilities and challenges for a wider adoption of them, the theory of diffusion of innovation by Rogers (1962; 2003), is used as a foundation for the research. As the study is based on theoretical considerations that allow for an exploration of the research question, a deductive approach is applied. In order to deduce the research question, it is subjected to empirical investigation through qualitative case study interviews. Qualitative research takes an interpretative, naturalistic approach to its subject matter, which means that the subject matter is studied in its natural setting. The intention is, by doing so, that one can understand and interpret the matter with regard to the meanings people bring to it. Through a qualitative approach, one can find description of the routine, meanings and problematic aspects in individuals´ lives (Denzin and Lincoln, 2005). As this thesis aims to identify, describe and explain the consumers' perspective and perception of electric vehicles and the current socio technical system surrounding the automotive industry, the qualitative approach is best suited for this study.

The qualitative approach allows for a flexible research with the intention of providing an in-depth view of different consumer groups in the social system of the automotive industry, and how their perceptions of the different aspects of vehicles and the industry can constitute possibilities or hinders for a diffusion of electric vehicles. The aim is to contribute to the research area where seemingly most studies have not taken the perspective of different customer segments (innovators, early adopter, early majority, late majority and laggards) and has thus not provided a general picture through a well-represented selection of all consumers within the social system. The intention is to, by including a selection of different consumer groups in the study, provide a picture that is as representative of the consumers within the automotive sector as possible in respect of the limitations of this research work (Bryman and Bell, 2011). Furthermore, the literature review

revealed that while several studies of consumer attitudes towards electric vehicles have been executed, few examples of literature include a selection of participants with both users and non-users of EVs, particularly in Sweden. Thus, an explorative approach is applied to this study. Moreover, interpretivism is used as the research of this thesis is based on a naturalistic approach of data collection through interviews, and as it is a commonly used approach for qualitative research (Gioia, Corley & Hamilton, 2013).

3.2 Research design and strategy

A qualitative case study design is utilized for this study in order to get an in-depth view of the topic. Research through a case study aims to scrutinize and analyze a particular case or multiple cases and intends to capture the complex state of the research matter (Stake, 1995). Furthermore, the case study design is applied as this thesis aims to capture the core values of the participants in a "particularistic, descriptive and heuristic" manner (Merriam, 2009, p. 46). The use of a case study design is further employed as it explores one or multiple contemporary bounded real life systems through detailed and thorough data collection (Creswell, 2013), which I assess as necessary in order to answer the research question of this thesis. Case study research has been defined by the unit of analysis, the process of study, and the outcome or end product, all essentially the case (Merriam, 2009). The aim is that this research design will provide an in-depth view of consumers' perception of electric vehicles and the currently dominating sociotechnical system, as well as the benefits and obstacles related to the adoption of electric vehicles. The intention is, by doing so, that the research question; "What are the main possibilities and challenges for expanding the adoption of electric vehicles in Sweden?" may be answered.

3.3 Data collection and method

3.3.1 Data collection

In order to collect the data needed for the analysis, interviews were conducted with twelve car owners. The respondents were chosen by their different consumer characteristics. In order to get a picture of the consumers within the industry that is as fair and transferable as possible, consumers that can be considered to have characteristics that are applicable to each of the consumer groups in the diffusion of innovation-framework were chosen. The case therefore includes two innovators, four early adopters, two early majority, three late majority and one laggard. The respondents that are categorized as innovators, early adopter and early majority are owners of electric vehicles. These participants were contacted through a large Facebook group with more than 10.500

members for people with electric cars, named "electric cars and electric hybrid cars in Sweden"[3]. The respondents that are categorized as late majority and laggard use ICE cars. These participants were contacted through a Facebook group for ICE vehicles. This group has 16.700 members and is named "Car-gatherings Sweden"[4]. The respondents were all aware that the interviews were voluntary and anonymous. The aim was that differences and or similarities in the experiences, values and perceptions of the different consumer groups could be observed and thus provide a representation of the differences and or similarities in consumer groups in the sociotechnical system of the automotive sector. The intention was that it would thus be plausible to identify the possibilities and hinders for achieving a diffusion of electric vehicles, not only among certain consumers, but throughout the entire socio-technical system and consequently reach critical mass, and a mainstream diffusion.

3.3.3 Respondents

The thesis employs a stratified sampling technique for the identification of key informants (Rowland & John, 2004). The stratified sampling technique is often used when the information or values of interest may vary between different subgroups and one wants to secure valid representation from all the subgroups. The stratified sampling technique increases the accuracy and representativeness of the results as it reduces the risks for sampling bias. This technique requires knowledge of the suitable characteristics of the sampling frame, which is obtained through the literature review and Rogers (1962; 2003) framework, where a description of the characteristics of different consumer groups (Innovator, early adopter, early majority, late majority, laggard) is presented. In this qualitative research, the stratified sampling strategy is intended to implement the broader goal of purposive sampling. Diverging the larger and general population into subcategories that are relevant for the research aim, thus contributes to a representative data collection that includes respondents from each of these categories (Given, 2008). Which of the categories the different participants were sorted into depended on their characteristics as consumers, which was decided through an interpretation of Rogers (1962; 2003) description of different consumer groups. Factors such as whether they have yet adopted an electric vehicle, for how long they have had their vehicle and their general tendency to adopt new innovations like electric vehicles, were considered. To simplify the description of the results, discussion and analysis, each of the participants were labeled with a participant id. Table 1 provides a presentation of the participants, their age, type of vehicle and location (urban, rural or suburban). However, due to integrity reasons, more detailed information that could reveal the identification of the participants have been excluded. As I advertised my study through open messages in Facebook groups where people could contact me if they were interested in participating in the study, the respondents were all very elaborative and willing to share their experiences and values in an in-depth and comprehensive manner.

[3] English translation from the Swedish name "Elbil och laddhybrid i Sverige".
[4] English translation from the Swedish name "Bilträffar Sverige".

After I received enough responses from volunteers of each consumer category, a list of the suitable interviewees was established (see table 1). The innovators are individuals who have used one or multiple electric vehicles for more than five years and were among the first to start using an electric vehicle. Very little needs to be done to appeal to these consumers. The early adopters are people who have used an electric vehicle for a couple of years but were not among the very first to adopt an electric vehicle. These consumers are very comfortable with trying new innovations but need some extent of information on implementation. The people included in the category, early majority, are people who have recently started using an electric vehicle and do not have more than two years' experience of it. They are not opinion leaders, but have started using EVs earlier than the average person. The participants in the late majority-category are people that are skeptical of change and will only adopt an innovation after it has been tried by the majority. These people use ICE vehicles and have never tried an EV. The participant representing the laggard category is very conservative and skeptical of change. This person owns an ICE vehicle and has never tried an EV.

Table 1. Respondents.

Consumer group	**Participant id**	**Vehicle**	**Age**	**Location**	**Date of interview**	**Brand/model**
Innovator	I1	Electric car	53	Suburban	March 22	Tesla model X
Innovator	I2	Electric car	61	Suburban	March 26	Tesla model 3
Early adopter	EA1	Electric car	48	Urban	March 25	Renault Zoe
Early adopter	EA2	Electric car	45	Rural	March 26	Tesla model S, Renault Zoe
Early adopter	EA3	Electric car	58	suburban	March 24	Tesla model S
Early adopter	EA4	Electric car	62	Suburban	March 29	Renault Zoe
Early majority	EM1	Electric car	52	Urban	March 24	Mitsubishi outlander
Early majority	EM2	Electric car	51	Urban	March 30	KIA e-niro
Late majority	LM1	ICE car	52	Suburban	April 12	Mercedes 200 CLA
Late majority	LM2	ICE car	26	Urban	April 13	Audi A6
Late majority	LM3	ICE car	55	Suburban	April 13	Audi A5
Laggard	L1	ICE car	49	Rural	April 15	Volvo XC60 D5

3.3.4 Interviews

The interviews in this study were of a semi-structured nature, which is a commonly used method for case studies (Bryman and Bell, 2011). The semi-structured method was adopted for this study as it provides the flexibility for the respondents to formulate and describe their own opinions and include additional thoughts or elaborations, to maintain the explorative nature of the research (Flick, 2009). Furthermore, the semi-structured interview technique gives the respondents the opportunity to steer the interview, to a certain extent, in a direction they think is relevant and

important. However, one interview guide was constructed for the respondents using electric vehicles, and a slightly different one was constructed for participants using ICE cars. The reason behind the two different interview guides was that the questions had to be slightly changed depending on whether the respondent used an EV or an ICE vehicle. While the interviews were semi-structured, the interview guides were intended to maintain the interview within the general frames of the research topic (Bryman and Bell, 2011). In order to fertilize the coding and to be able to do a structured analysis of the collected data, the interview guides were developed after the five determinants of adoption rate discussed in the diffusion of innovation-framework (Rogers, 1962; 2003). Thus, the interview guides were structured after the five categories; relative advantage, compatibility, complexity, trialability, observbility.

In addition to the two interview guides, follow-up questions were in some cases asked in order to clarify the respondent's answers and encourage the person to develop on what they considered to be important information, and also to ensure that all the data needed for the analysis was collected from each respondent. This allowed for more informative interviews where in-depth information could be obtained. Prior to the interview, I sent the respondents the interview guide I was going to use and provided more information about my study. The technique of laddering questions was used to create a more thorough understanding of the subject discussed. This technique assisted in reaching saturation by asking questions until everything relevant was explored and no newer insights emerged (Reynolds & Gutman, 1988). All of the interviews were scheduled at the end of March and beginning of April. Due to the global pandemic, and the varying locations of the respondents, all of the interviews were conducted via Microsoft Teams. Furthermore, all of the interviews were conducted in Swedish as it is both mine and the respondents' native language. The interviews lasted for 30 to 45 minutes and were audio recorded upon consent from the interviewees, in order to ensure that the information provided by the respondents were accurately captured. In addition, recording the interviews allows the interviewer to dedicate full focus on the respondent's answers so that relevant follow-up questions can be asked, and any contradictions can be questioned (Bryman and Bell, 2011). The audio-recordings were then transcribed so that the data could be coded and analyzed against the background of existing literature.

3.4 Data analysis

In order to find meanings, relationships, themes and structure of the collected data, a content analysis was employed (Gioia & Pitre, 1990). The data was first summarized and structured into first cycle codes through process coding and in vivo coding. The summary of the first cycle codes were then divided into a smaller number of categories through second cycle coding, namely (i) possibilities and (ii) challeges, with subcategories (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, (5) observability. For this qualitative case study, the second cycle

coding laid the groundwork for the analysis as it fertilized the identification of common themes within the categories among the respondents. The process of the data analysis included going back and forth between theory and the data (Gioia et al., 2013; Marshall & Rossman, 1995).

3.4.1 First cycle coding

Following the transcription of all the interviews, I used deductive coding to identify relevant themes and important trends within the different predetermined categories (relative advantage, compatibility, complexity, trialability, observability) for each consumer group. By doing so, I could distinguish certain aspects or values that were similar for the respondents in general, or within their respective category. Relevant information from each interview was coded and sorted in a separate document, resulting in a number of primary codes from the different interviews that were arranged into different categories. A summary of the first cycle codes can be observed in table 2 below.

Table 2. First cycle codes of different consumer groups perception of electric vehicles and the automotive system.

	Primary codes				
	Relative advantage	**Compatibility**	**Complexity**	**Trialability**	**Observability**
Innovator	a) Environmentally beneficial in relation to ICE. b) Relatively lower fuel costs. c) Range used to be a worry, not anymore. d) Price is relatively higher for EV, but worth it.	a) Social status is a factor, but not important to these consumers. b) The innovation is compatible with consumers' sustainability values. c) EVs are incompatible with infrastructure and the social system.	a) EVs are perceived as easier to use than ICE. b) Limited opportunities for home charging by apartments.	a) Got convinced to start using EV after trying. b) Took initiative to ask for/try an EV.	a) Aware of detailed impacts of using EV such as how much less co2 emissions. b) Have seeked out information about EVs themselves.
Early adopter	a) Environmentally beneficial in relation to ICE. b) Relatively lower fuel costs. c) Range used to be a worry, not anymore. d) Price is relatively higher for EV, but worth it.	a) Social status is a factor but not important to these consumers. b) The innovation is compatible with consumer's sustainability values. c) EVs are incompatible with infrastructure and social system.	a) EVs are perceived as easier to use than ICE. b) Limited opportunities for home charging by apartments.	a) Got convinced to start using EV after trying. b) Took initiative to ask for/try an EV.	a) Aware of detailed impacts of using EV such as how much less co2 emissions b) Have seeked out information about EVs themselves.
Early majority	a) Environmentally beneficial in relation to ICE. b) Relatively lower fuel costs. c) Range can be an issue. It takes more planning. d) The relatively higher price made these consumers hesitate, but believed it was worth it.	a) Social status is a contributing factor to why these consumers adopted an EV. b) The innovation is compatible with consumers' sustainability values. c) EVs are incompatible with infrastructure and social system.	a) EVs are perceived as easier to use than ICE. b) Limited opportunities for home charging by apartments.	a) Got convinced to start using EV after trying. b) Got advice/information from someone in their proximity.	a) Aware of detailed impacts of using EV such as how much less co2 emissions b) Have received advice from individuals in their social circle. Have seeked out additional information about EVs themselves.
Late majority	a) Environmentally beneficial in relation to ICE. b) Lower fuel costs. c) Range seems like one of the largest issues with EVs. d) The price of EVs is too high.	a) These consumers perceive EVs as status products. b) values related to sustainability are not as present in this consumer group. c) EVs are incompatible with infrastructure and social system	a) EV seems harder to use. b) Complex charging system.	a) Have not tried nor gotten the opportunity to try an EV.	a) Not aware of the exact impacts of using EV. b) Have not received detailed information about EVs nor searched for information.
Laggard	a) Environmental aspect. b) Range seems like one of the largest issues with an EV relative to ICE. d) The price of EVs is too high.	a) Does not perceive EVs as a status product. Believes that other ICE cars constitute more social status. b) values related to sustainability are not important to this consumer. c) EVs are incompatible with infrastructure and social system.	a) EV seems harder to use. b) Complex charging system.	a) Have not tried nor gotten the opportunity to try an EV. b) Does not have a desire to try an EV.	a) Not aware of the exact impacts of using EV. b) Have not received detailed information about EVs nor searched for information.

3.4.2 Second cycle coding

After a summary of the first cycle codes had been established, they were interpreted and arranged into second cycle codes (Gioia et al., 2013). By reviewing the first cycle codes, I could identify similarities in the responses between the different groups and categories and identify the possibilities and challenges for diffusing EVs, not only among consumer groups who tend to adopt innovations early, but also among the critical mass of the consumers in the social system (Marshall & Rossman, 1995). The primary codes were thus sorted into the two main categories- possibilities and challenges, with the five subcategories; relative advantage, compatibility, complexity, trialability, observability (see table 3 below).

Table 3. Second cycle codes of possibilities and challenges for expanded electric vehicle adoption in Sweden.

	Secondary codes	
	Possibilities	**Challenges**
Relative advantage	*Environmental effects:* General knowledge of the existence of environmental benefits of EVs among all consumer groups. *Cheaper fuel:* Lower cost of fuel relative to ICE vehicles	*Battery range:* Driving an EV requires more planning. Perceived as a larger problem for EM, LM and L, than for EA and I. *Price:* The purchasing price is relatively more expensive for EVs than for ICE cars. This is relatively more important for LM and L than for I, EA and EM.
Compatibility	*Compatible with social status (*mostly appealing to EM and LM), *and sustainability values* (mostly appealing to I, EA, EM, LM).	*Infrastructure:* Current infrastructure not built for EVs. Complex payment systems related to charging. Complementaries lagging behind creating bottlenecks.
Complexity		*Perceived as complex to use by consumers without experience:* Perceived as complex to drive by non-EV users. Believed to be too complex to charge and maintain, by non-EV users.
Trialability		*Limited opportunities to test the innovation prior to commitment:* Few opportunities to try an EV. *Intangible results:* No tangible results of driving experience or usage for consumers who have not tested the innovation.
Observability		*Insufficient information*: Consumers have to seek out information themselves and consumers who do not do this (LM, L) are not informed. *Limited possibilities for proximity observation:* EVs are not yet diffused to the extent that most have somebody in their proximity that uses an EV, and the innovation can thus not be observed through proximity.

3.5 Credibility and trustworthiness

In order to achieve trustworthiness to the greatest extent possible in a qualitative study, this study was characterized by transparency. Given that the interviews were of a semi-structured nature, there are limitations to the consistency of the answers across the different respondents. Moreover, it should be emphasized that the study is based on the responses of different individuals with individual opinions and perspectives, which could influence the answers. Therefore, some level of subjectivity is inevitable for this type of study, which should be taken into consideration by the reader (Bryman and Bell, 2011). As the data for the study was only obtained from twelve respondents, there are limitations to the transferability of the results. However, in order to achieve as high a level of external credibility as possible, it is of great importance to examine consumers that differ from one another. A certain width of the sample was achieved by selecting different consumer groups, in accordance with Rogers (1962; 2003) framework. However, one should be aware that the size of the sample cannot completely represent the industry which can affect the credibility. Therefore, it should be stated that the conclusions of this study are not definite and might need further studies (Bryman and Bell, 2011).

3.6 Limitations

The limitations of this study are primarily a consequence of time constraints affecting the possibilities to study a larger sample of consumers in order to collect more data. The limited sample size restricts the transferability of the results and while the aim is to achieve as high transferability as possible within the frames of the time restrictions, the conclusions drawn from this study might not be entirely general to the industry, social systems or socio-technical regimes. Moreover, there are limitations to the credibility of the data as the semi-structured interviews may be characterized by some subjectivity. However, the approaches and methods of the study are adopted to provide as much credibility and transparency as possible.

Furthermore, due to the restrictions of social contact during the time period of this research, as well as the varying location of habitation of the different respondents, the interviews were conducted through online video calls. This may have affected the interviews as it sometimes can cause disruptions of the flow of a conversation (Weller, 2015). It can also be more difficult to read the facial expressions of the respondent in a video call than in a face to face interview, and thus the study may include limitations in the sense of context of the interview (Iacono, Symonds & Brown, 2016; Weller, 2015). Furthermore, the interviews were conducted and transcribed in Swedish and subsequently translated to English. Some of the typically Swedish expressions were hard to translate adequately and thus some of the tonality or accuracy of the responses may have been lost in the English translation of the interviews.

4. Empirical analysis

In this chapter the results from the interviews with the twelve different car owners are presented and analyzed. The analysis is structured after the five main determinants of rate of adoption developed by Rogers (1962; 2003), under which a number of different themes have been distinguished from the data collected in the interviews. Subsequently, the possibilities and challenges for achieving an expanded consumer adoption of electric vehicles in Sweden will be identified. This will be presented in accordance with the data coding explained in chapter 3 (see tables 2 and 3).

4.1 Determining factors for the rate of adoption

4.1.1 Relative advantage

The degree to which an innovation is seen as better than the idea, program, or product it replaces is one of the determining factors for the rate of adoption of an innovation (Rogers, 1962; 2003). The degree of relative advantage can be measured in financial terms, but can also be measured by social prestige, convenience or satisfaction. The consumer's perception of the innovations relative advantage should be in focus, rather than the objective advantage of the innovation. The larger the perceived relative advantage of an innovation, the more rapid rate of diffusion of it. The results indicate that all of the drivers of electric vehicles in the study perceive the relative advantage to be larger for electric vehicles than for ICE vehicles, as the participants who are EV drivers view the benefits of driving an EV as larger than the challenges that come with it. Additionally, the answers indicate that the ICE car drivers' perceptions of the relative advantages of electric vehicles are fairly similar to the EV drivers' perceived benefits with EVs. However, the ICE car drivers consider the relative issues and challenges of using an EV to be larger than the relative benefits, and therefore hesitate to accept electric cars as a replacement for ICE cars. Through coding procedures, four main themes of the consumer's experiences and opinions could be identified within the category of relative advantage; "environmental effects", "cheaper fuel", "price" and "driving range". These themes will be discussed in terms of the possibilities or challenges they constitute for the expansion of electric vehicle adoption in Sweden.

Environmental effects: Many drivers mentioned positive environmental effects as a primary benefit with electric vehicles. Most of the participants who were users of electric vehicles named the environmental benefits of EVs as the main aspect that convinced them to try and adopt an EV as a replacement for their ICE car. Several of the EV-users describe that prior to their purchase or commitment to leasing contract, they had an uneasy feeling about driving their ICE car. While the EV-users named several benefits, all except one of them pointed to the environmental factor as the

primary benefit related to the usage of an electric vehicle. Furthermore, three out of the four ICE car-users also named the environmental benefits as the primary positive factor when asked about what they view as positive effects of using an EV. The fact that the environmental aspect of EVs is the primary benefit, not only in the view of consumers who have already adopted EVs, but to consumers that do not have as much knowledge about the innovation, implies that the information about EVs has primarily been focused on the environmental aspects related to the innovation. It could further mean that while the benefits related to sustainability have been clearly communicated to both consumer groups who tend to adapt to innovations early, and consumers who tend to adapt to them late, other benefits have not been as vividly communicated to late adopters and laggards. Thus, they still perceive the negative aspects of using an EV to be larger than the sum of the positive effects.

> *"For me, the environmental aspect is the driving force. Tesla is a special car with software updates, etc., but that is not the most important thing to me, it is the environmental benefits that comes with driving an electric car."* (I1)

> *"Our decision to switch to an electric vehicle largely depended on the environmental aspects. We had a gas-driven car for eight years and we drove it on gas most of the time, and petrol a few times. For us, it is the environmental aspect that is important."* (EM1)

> *"The primary benefit is probably that electric vehicles have less environmental impact."* (LM1)

While the majority of the respondents regardless of consumer category, responded that they perceive the environmental aspect as the most important benefit of driving an electric vehicle, the EV-users generally had more knowledge and interest in the specific environmental impacts of driving an EV relative to an ICE. For example, two respondents categorized as early adopter and late majority expressed the following:

> *"I have commuted a lot with ICE cars back and forth from work. I have driven 2000 kilometers per year and that is about three tons of CO_2 per year, which adds up to a lot over the years. There is only one answer; the environment. That is the most important aspect that made me make a change. That is the primary answer. Number two: I have given "Statoil" 200,000 SEK at the expense of petrol for 20 years. So in 2015 I thought about different options. There is private commuting and bus commuting and that is the cheapest way to get around, but you have to pay with your time. So I started looking for electric cars."* (EA 4).

> *"No. I am not aware of the exact results per se. I know that there are less emissions, but I cannot say that I know anything more specific than that exactly."* (LM2).

This implies that while the ICE vehicle-users are aware of the environmental impact in general, they have not looked into the matter thoroughly and thus there might be an issue related to tangibility for these consumers which may decrease the perception of a relative advantage of EVs in terms of the environmental effects. It seems to be difficult for them to fully apprehend the practical environmental impacts of an ICE car versus electric car. The EV drivers on the other hand, seem to have a larger interest in consuming information about the specific parameters related to the environmental impact of different vehicles and thus the impacts of driving an EV are more tangible to them.

Relatively lower costs related to fuel: The data further reveal that relatively lower costs for fuel is another aspect that many of the participants view as a positive effect of electric vehicles. All of the participants except for EM2, EM3 and L1 mentioned lower fuel costs of electricity relative to other fuels like petrol, as one of their perceived benefits of EVs. For some of the respondents, the lower cost of electricity as a fuel relative to for instance petrol, was in fact one of the main reasons why they decided to adopt an EV. Respondents EA2 and I1 describe this as follows:

> *"I drive a lot because I work in Copenhagen. This means that I drive around 45,000 kilometers a year. So in my case, I can save a lot of money by driving an electric car because it is much cheaper to charge it than to fuel up an ICE car for example. So an aspect that was important to me was the economic aspect because I save around 50,000 SEK a year just for fuel costs."* (EA2).

> *"The main reason I started using an electric car instead of an ICE car is that an EV offers a much cheaper monthly ownership than an ICE car does. It is simply cheaper to drive an EV in the long run."* (I1).

The fact that the consumers who already own or lease an EV are aware of the fuel costs of an EV relative to an ICE car is not surprising as they have experience of managing the charging and the costs of it. While one of the respondents who drive an ICE car mentioned lower fuel costs as a perceived benefit with EVs, the three remaining ICE car drivers did not seem to be aware of, or consider it to be a benefit, that the costs for electricity is cheaper than the costs for petroleum.

Price: The results suggest that price is another important factor that was taken into consideration by all of the consumer groups in this study. Most of the ICE car-users identified the price as one of the main reasons why they had not yet committed to an EV. The purchase price of most EVs is relatively higher than for ICE cars, which in the non EV-consumers' views is seen as a largely negative aspect of EVs. In addition, many of the EV-users also mentioned that the relatively higher price for EVs was a negative aspect that they had to consider when making the decision to

transition from an ICE car to an EV. For example, respondent EM2 states the following:

> *"Yes, it is impossible not to reflect on the price. In my family we also drive quite little, so we are not able to make it up by saving money because of the fact that electricity is relatively cheaper than fossil fuel. So yes, electric cars are expensive, that is impossible to get away from. We wish there was not such a big price difference, but we thought it was worth the price to go environmentally friendly, quite simply put."* (EM2).

While most of the respondents in the categories "innovator", "early adopter" and "early majority", who are already EV users stated that the relatively higher price was a disadvantage, all of them claim that the car was worth the price. This suggests that the willingness of these consumer groups to adopt the innovation was large enough to commit to it regardless of the price. As the more skeptical consumer groups are not as willing to adapt to an innovation, they do not overlook the relatively high price of EVs in the way that the other consumer groups do. Thus, the price of EVs may constitute an obstacle for diffusion of EVs among consumers within the categories, late majority and laggards. It should also be mentioned that higher income will likely have an effect on a consumer's willingness to adapt to relatively more expensive new innovations. Although the income of the consumers was not disclosed in this study, it likely impacts the consumers' perception of the price factor and may have an effect on the consumers' willingness to adopt electric cars. Despite the higher price of EVs, various of the EV drivers stressed the fact that the price is successively reducing as the battery technology is developing. This could mean that the price will constitute less of an issue in the near future. Respondent EA2 describes the following:

> *"In general, electric cars are expensive and that is because the batteries are expensive, but battery prices have also fallen quite a bit lately. The prices of fossil-powered cars have also increased, which means that if you are to take a fully equipped large fossil-powered car and compare it with a fully equipped large electric car, the price difference is not that huge anymore. It shrinks with each passing year, especially since battery prices are going down. I did not make a switch straight off from a fossil fuel car to an exactly the same size electric car, but a few years ago the price difference was greater than it is now so that distance is shrinking."* (EA2).

Driving range: According to the data collected in the study, the limited range of one fully charged battery is perceived as a negative factor for some of the consumers. As the driving range of one "full tank" in an EV is perceived as much shorter than the driving range of one full tank in an ICE car, the battery range is one of the main obstacles recognized by the non-EV users. Furthermore, many of the EV-users explain that driving an EV requires a certain amount of extra planning, in

particular when one is making long distance trips. One of the early adopters describe this issue in the following manner:

> *"Well, to some extent you have to plan your driving in relation to the charging stations. When you drive to the south of Sweden, there are no problems because the charging stations are so densely built. We have only had problems once. That was when we were going up to Mora in the north and the charging station we had planned to charge at was broken. So we had to slow-charge and wait for maybe five hours before we could move on. But that is the only time in three years that we have experienced that kind of large problems with range."* (EA3).

While most of the consumers state that the limited driving range of EVs can be seen as an issue, some of the EV-users argue that it is not as problematic as many people may think. Most of the consumers in the groups "innovator" and "early adopter" claim that while they were initially slightly worried about the driving range, they gradually understood the range is seldom an issue, especially not in their everyday use of the electric car. Moreover, many of the EV-users discuss that the driving range is rapidly improving due to the sharp advancements in battery technology. Two respondents from the categories "early adopter" and "innovator" respectively state the following:

> *"It has gotten better and better over the years. The first electric car we had went about 180 kilometers in the winter and since I drove 10-140 kilometers every day only because of work, it became a little problematic. So that is why we switched to a used tesla model S, because it had a better range. Then we thought it was a bit big after a year or so, so then we switched to a model 3 after a year that suited us better in size plus it had an even better range than model S. So it depends a lot on which car you buy but in general, all cars get bigger batteries over the years. It's a bit like performance or battery life on cell phones. Electric cars are also getting better and more advanced with each passing year. Renault Zoe has been around for a very long time, seven years, I think. In the beginning it had a fairly small battery, but the one we got now in December has a fairly large battery. So, there is a development just like on other fronts such as computers etc. Electric car batteries are getting cheaper and cheaper and then you can put bigger and bigger batteries in the cars. So, it depends a lot on which car you buy. Batteries are very expensive, so large batteries result in more expensive cars. Then of course there is brand hype as well. Audi charges a lot for their EVs even if they do not have larger batteries, while other brands such as Nissan are more reasonably priced, even if there is not much difference in battery capacity. But in summary, capacity has simply increased over the years."* (EA2).

> *"With our previous car, we decided to try to use it as our only car. We still had our old diesel car too. But then we sold the diesel car and just used the electric one. We went on longer road trips both in the summer and the winter with the electric car, but of course you had to stop quite often and charge. The range in the winter is shorter than in the summer because some of the battery capacity is used for heat, so the range was at best 110-120 kilometers with that car then. Now it has become much better in that respect of course, but that range was actually enough for all everyday needs. You just had to plan the drive a bit if you were to go far. Now that I have a Tesla with a large battery and Tesla's charging network and charging speed, all that in combination makes it not a problem anymore. Of course, I have to check where I am going to charge if I am going to travel very long distances, but that is not a problem to me."* (I1).

These results imply that, while the driving range has been an issue that has been viewed as a relative disadvantage compared to ICE cars, the range has increased immensely in merely a few years as the capacity of the batteries have improved rapidly. EV-models that are currently being introduced to the market therefore have a battery capacity that allows these EVs to almost match the range of fossil fuel cars, and looking at the current development, it is not unlikely that the range will be just as sufficient for EVs as ICE cars in a few years' time. However, it seems like the image of EVs offering a problematically low driving range, still remains among consumers that have not yet adopted an EV. One of the non-EV users state:

> *"My opinion is that the range of one fully charged battery is too short and there is still a shortage of charging stations and that is what makes us hesitate. I think it can be a problem and you have to plan your driving more. I have heard others say that they have to plan their route after the charging stations. So that was what affected us, among other things. It seems a bit cumbersome and requires a lot of planning I think."* (LM1).

The data thus suggests that the driving range in itself is perceived as a relative disadvantage, mostly by non-EV users, due to a lingering image of EVs as worse performing vehicles. However, changing this image could be quite easy and some may argue that it is already in process of being shifted as large vehicle manufacturers are starting to produce and market EVs rather intensively. It is however possible that not the driving range in itself, but the infrastructure related to charging, may hinder EV-usage and require increased planning. Overcoming the obstacle of the driving range may therefore not only depend on advancements within battery technology, but will require a comprehensive expansion of the infrastructure of the charging systems, which is a larger issue. This will be further discussed under "compatibility" (4.1.2).

4.1.2 Compatibility

As Rogers (1962; 2003) describes in the diffusion of innovation-framework, one of the determining factors for the rate of adoption of an innovation is the innovation's consistency with the values, experiences, and needs of the potential adopters. An innovation or idea that is not in line with the values and norms of a social system will not be adopted as rapidly as a novelty that is compatible. An adoption of an innovation that is incompatible with the social system often requires an adoption of a new value system first, which is a very time-consuming process. While some positive effects related to electric cars were found within this category, the data from the interviews suggest that themes related to compatibility may be some of the most challenging for an expansion of the electric vehicle adoption. While several of the respondents had positive perceptions of the social status and environmental beliefs related to electric cars, most of the interviewees stated that the infrastructure surrounding electric vehicles and its incompatibility with the current social system, can be a substantial issue. The themes that were identified and will be discussed within the category "compatibility" are thus: "compatible social status and sustainability values", and "infrastructure".

Compatible social status and sustainability values: In order to achieve adoption of a new innovation, it is important that the innovation is compatible with the consumers' values, image and norms. Social status is a factor that some of the respondents perceive as a benefit of driving an EV. Social status is a significant factor when it comes to adoption of new innovations. However, the perceived status related to EVs seems to be more connected to certain brands such as Tesla, than the EV in itself. Furthermore, while consumers from the groups 'innovator' and 'early adopter' certainly acknowledged that there is some extent of social status surrounding EVs, it is not a predominant aspect to them. One of the early adopters explains this in the following manner:

> *"For me, it actually had nothing to do with status but rather that we needed to access a larger car at the time we bought the Tesla. We wanted to do some road trips in Europe and such and therefore we chose a used Tesla model S because it had the size, range and Tesla's own charging network. Tesla is cool but there are other cool cars too, so for me it was not very much about the aspect that it is cool. That was maybe 4-5 years ago and there may be others who think it is cool, I do not know. For some it may be a status thing, but for me it is absolutely not important."* (EA3).

As was discussed under relative advantage, many consumers also view the environmental aspect as one of the main benefits with EVs, and the sustainability aspect of the innovation was the main reason behind most of the EV users' decision to adopt the innovation. The results thus imply that it is very important that the innovation is compatible with the consumers' beliefs as sustainability

values are perceived as an important aspect related to EVs. While the non-EV users also acknowledge the environmental benefits of electric cars, their sustainability values do not seem to be as strong as the consumers within the categories, 'innovator', 'early adopter' and 'early majority', and thus the environmental advantage of electric cars does not outweigh their perception of the obstacles of using an EV.

Infrastructure-a bottleneck effect: The data implies that the infrastructure surrounding electric cars is a substantial obstacle for a wider adoption of EVs. Both the EV-users and the ICE car-users view the infrastructure related to charging as a big challenge. Several of the respondents highlight the need for an expansion of the charging infrastructure. Most of the EV-users describe the charging system as quite unorganized with inferior administration of the payment system for electricity charging. Moreover, some consumers explain that there is a great need for a larger number of charging stations and charging poles, in order to simplify the usage and reduce the need for planning the routes around existing charging stations. Moreover, some EV-consumers explain that as the usage of EVs has increased in the past few years, the charging stations have become increasingly occupied, which is a substantial issue for EV drivers. Two of the respondents from the categories "early adopter" and "early majority" describe the following:

> *"Another aspect that I think is important to achieve the spread of electric cars is to develop the charging networks. I think this is an extremely critical factor, because many do not dare to buy an electric car because of this. They think "we are going to visit aunt Anna in Västerås, can we drive there with an electric car?". Yes, they can, but they have to read a little and understand aspects of charging networks and their payment solutions, and that's too complicated right now. There are actually solutions that allow you to pay on several different actors' charging posts via an app or a tag, but then it costs a lot of money. They charge for that function so that instead of costing 5 SEK per kwh it may cost 12-13 SEK and then it will be more expensive to drive an electric car than a fossil fuel car. This means that people do not dare to take the step. So, a simplification is required and perhaps even a price reduction on the players' fast charging network are aspects that could really put the whole thing in motion and would have made people dare to take the step. Then people might realize that not only short distances work fine with an electric car, but that it actually works well and in a decent economical way for long journeys as well."* (EA2).

> *"I hope they build the fast charging infrastructure at a sufficient pace. OKQ8 and others are building infrastructure, but I imagine it will be a problem in some places in certain geographical areas. Then it is probably seasonal as well. For example, it is an issue at the McDonalds in Kristinehamn for all of us who live in Västra Götaland who are going to the mountains to ski at the same time each year, with only two fast chargers. I do not dare to think of a cottage change day*

> *there. So, the infrastructure must be expanded. If everyone is to drive an electric car, there must be destination chargers in much larger quantities, in public spaces and also those who receive visits, e.g. hotels and grocery stores and such. But fast chargers I see as a big challenge."* (EM2).

Another aspect of the infrastructure that is important to consider is the possibilities for charging at home. Some of the respondents explain that it may be problematic to charge an EV at home if you live in an apartment and not a house. While it is possible to install charging boxes in a house, house cooperatives and tenancy associations usually only offer a small amount of parking spots with charging, if any at all. This creates a situation where it is almost necessary to own a house in order to get an opportunity for home charging. Thus, it is still easier as a consumer not to adopt an electric car and use an ICE car as the complementaries related to an ICE are still more developed and adapted to most consumers' living standards.

> *"I think that there are issues related to charging in residential areas with condominiums, townhouse areas and such, where it can be a bit problematic so it is probably necessary to think a little about how to make it easy for people who do not live in a house."* (EA3).

The infrastructure surrounding EVs can indeed be considered a bottleneck that may greatly hinder the rate of adoption of EVs. The charging infrastructure and payment system are two very necessary complementaries that are required to develop and advance simultaneously with the innovation in itself, if the diffusion of electric cars is to be possible. The data suggests that these complemetaries are not improving at the same pace as the performance and quality of electric cars themselves, which will be a large challenge when it comes to reaching a wider consumer adoption of electric cars. It is crucial that the complementaries like the charging infrastructure and payment system related to it, develop at a similar rate as electric cars and the rate of consumer adoption of them, for them to continue to diffuse. If the necessary complementaries do not keep up with the advancement of the actual innovation, the rate of adoption might stagnate and it will be difficult to accelerate the diffusion. Furthermore, while the social regime seems to currently be undergoing a slight transformation where subsystems such as the Facebook group where I came in contact with the EV-users are emerging, the general social system built around the automotive sector is largely structured after ICE vehicles. The results imply that the consumers perceive ICE car usage as the norm and thus, all of the complementaries needed for a vehicle are accommodated to ICE vehicles and not EVs, which indeed is an obstacle for reaching a wider EV adoption.

4.1.3 Complexity

How difficult an innovation is to understand and/or use, namely the complexity of an innovation, can determine the rate of adoption of an innovation and it is thus an important factor to consider in terms of consumers' perception of the innovation. As stated by Rogers (1962; 2003), some innovations are easily understood by the majority of the members in a social system, but some are more complex and harder to comprehend or use. An innovation that is hard to understand or use will result in a slower adoption of it, and innovations that do not require adopters to develop new skills and knowledge are adopted more rapidly. In the empirical study, the main theme that was found in this category is: "perceived as complex to use by consumers without experience".

Perceived as complex to use by consumers without experience: The complexity of a new innovation is an important factor deciding the rate of adoption of it. The data from the interviews imply that EVs are seen as complex products for consumers who have not tried using an EV. Several of the non EV-users describe that they think that it may be complex to use an EV, partly because the electric car is a fairly new innovation and has new features, and partly because the complementaries built around the automotive industry are not adapted to EVs to the same extent as the complementaries related to fossil fuel cars. Consequently, the usage of EVs is perceived as more complex. One of the ICE car-users describe this in a following way:

> *"The whole market and society are still built for fossil-powered cars rather than for electric cars. So, it is probably based on too little information, but I think that electric cars are more complex than fossil cars, but on the other hand I have never tried one."* (LM3).

While most non EV-users perceive electric cars as complex and difficult to use, EV-users claim that the image of EVs as a complex product is created from a lack of knowledge. Several of the EV-users state that an electric car is in fact much easier to understand while driving than an ICE car. Two of the respondents from the consumer groups "early majority" and "early adopter" state the following:

> *"It is much easier to understand an electric car. It was almost as if you were confused about how easy it was. If you drive an ICE car, you must press the start button and ignition and traction mode, etc. But with my electric car it is just start and go. So, it is much easier to use than a fossil fuel car, I think."(EM1).*

> *"It's easy. What you have to learn are perhaps more abstract things like "how far can I drive this car?" and "how do I charge it when I'm driving?" etc. But it is easier to drive an electric car. There are no gears, for example. The practical*

> *use is very easy, and it only takes a few times of practice to plug in the cord when you charge at home. The big differences are mostly when you have to make a little longer trips, where you have to have knowledge of charging networks and questions such as "it is not possible to pay in the same way as you do at a gas station when you have to stop and charge somewhere?" Only Tesla has a really good solution in that respect. There are far too many charging networks, or too many chargers with too many actors. That is a big obstacle today, I think. So, if you drive a bit up towards Gothenburg and the car signals that you have to charge and you drive into a charging station, then you do not really know how to pay. It can be a "tag" or it can be an app and so on. If you are unlucky and drive to Stockholm, you may need three different apps or something because there are so many different payment systems with the charging networks. So that part is quite difficult, but just driving an electric car is very easy."* (EA2).

This suggests that the view of the electric car as a product that is complex to use, is to some extent a matter of misinformation and fear of what is unknown and outside of the general norm. As the innovation is yet only diffused among consumer groups that actively seek information and opportunities to test new innovations themselves, the information is only communicated in their own small innovation-friendly social system through communication channels such as Facebook groups or articles targeting individuals who have already adopted electric cars. It also highlights the importance of getting an opportunity to practically implement the innovation as a consumer, in order to understand it. However, many of the EV-users highlight that while the electric car is easy and user friendly during propulsion, the complexity related to complementaries such as the charging system or the organization of payment systems for the charging, can be problematic. Some of the EV-users state that this type of complexity may be one of the contributing factors to why electric vehicle adoptions have yet to expand more widely.

4.1.4 Trialability

The extent to which the innovation can be tested or experimented with before a commitment to adoption is made, is another determining factor of the rate of adoption of new innovations. If new innovations can be tried on the installment plan, they tend to be adopted more rapidly than novelties that are invisible. An innovation or new idea that is triable will reduce the uncertainty for consumers that are considering adopting it as they can gain knowledge by trying the novelty (Rogers, 1962; 2003). The opportunity to try electric vehicles may thus be vital for the expansion of electric vehicle adoption among Swedish consumers in the automotive industry. Many of the respondents stated that they perceive the trialability for electric vehicles as limited. Most of the ICE car drivers also highlighted that they find the results or effect of driving an electric car as quite intangible. The main themes that are discussed in the category "trialability" are thus: 'intangible results and limited trialability'.

Intangible results and limited trialability: The data collected from the interviews suggest that, while some of the benefits with adopting an EV are very evident to the consumers who have already accepted the innovation, they are fairly intangible to the consumers that have not yet adopted it. Consumers who drive ICE-cars are not completely aware of the exact effects or results of an EV or what the exact practical usage looks like, which brings some uncertainty upon the innovation and may thus be an obstacle for a wider adoption of electric vehicles. This could be due to a lack of information about the functions, features and effects of electric cars, creating a general view of EVs as a complex product. It could also be due to the fact that the currently dominating socio-technical regime has been present for so long and is so deeply rooted that the knowledge related to the regime is strongly integrated with the entire socio-technical system. Substituting products such as electric cars and their complementaries may thus entail a steep learning curve that frightens consumers of adopting the new innovation as it will require effort to pass that learning curve in order to adopt a new innovation. One of the respondents from the consumer group "late majority" states:

> *"I have never tested an electric car, so I am not aware of how it works in practice. I do not know how the experience would have been, but I know that there are environmental benefits and that you have to charge it and so on, but I do not know exactly the differences between an electric car and a fossil fuel car."* (LM3).

However, the results imply that consumers who have tried driving an electric car perceive the driving experience as very simple and user-friendly with non-complex user features. Despite the charging infrastructure and related payment system that are described as slightly problematic by some EV users, the data suggests that given the opportunity to try using an electric car, the consumer's view of electric vehicles as a complex innovation could quite easily be changed. None of the ICE car drivers of the study had tested an EV at the time of the interviews and both the EV-users and the non EV-users stated that it seems rare to be given the opportunity to test driving an EV. This may be due to limited possibilities of connecting with someone in one's proximate social network that could offer information and trial of an electric car due to the, still limited, diffusion of electric vehicles. Furthermore, several of the respondents state that they have not been offered to try an EV in the process of purchasing a new car, nor have they been offered information about EVs. Most of the EV-users highlight that they have demanded information or practical trials of electric cars themselves, in the purchasing or leasing process. One consumer describes the following:

> *"I do not have anyone in my social circle that I could have asked to try an electric car, so it has not happened. Otherwise I would probably have tried, but I have not actively attempted to try one. I mean, I could have maybe asked for it*

> *when I was in the process of buying a new car, but that was not really an option for me due to other factors that I viewed as negative with purchasing an electric car."* (EM2).

4.1.5 Observability

As described in the diffusion of innovation-framework (Rogers, 1962; 2003), the rate of adoption of new innovations is dependent on the extent to which the innovation provides tangible results, and results that are observable to others. The more visible the results of an innovation are to individuals, the more likely it is that they will adopt the innovation. Visibility often causes discussions within the social systems and friends or neighbors tend to ask for information and learn further about the innovation. The data collected from the interviews suggests that there is a lack of sufficient information about electric cars, their complementaries and workings. Most of the respondents, both EV-drivers and ICE car-drivers, state that they find the information about EVs to be scarce and that one must look for information oneself in order to take part of it. Furthermore, several of the respondents state that the possibilities to observe electric cars and their features in one's proximate social network, are limited. The two main themes identified in the category "observability", are thus: 'insufficient information' and 'limited possibilities for proximity observation'.

Insufficient information: The results show that consumers generally find the information about electric vehicles insufficient. The consumers who have already adopted an EV state that information about electric cars and their effects is available, but the information is not distributed among mainstream consumers, and as a consumer you do not get introduced to EVs and their features without making an effort yourself. This suggests that there are limitations to the way in which information about electric cars is communicated. While information regarding different aspects of driving and purchasing an EV is available, it seems to be limited to certain smaller parts of the social systems with limited communication channels that do not reach the entire current socio-technical regime. For instance, there are Facebook groups, journals and YouTube channels dedicated to sharing information about EVs. However, these communication channels only reach a restricted part of the social system with members that are interested in, and seek for, the information themselves. The members in this part of the social system have already accepted, or are open to accept, new innovations. The consumers that should be targeted if a wider consumer adoption of electric cars is to be achieved, are not included in this part of the social system and because they are not curious enough about new innovations to seek these information forums themselves, they are not reached by the knowledge. In order to reach a critical mass of consumer adoption, it may thus be vital to create stronger communication channels, and great marketing strategies dedicated to expanding the social system where information, norms and culture related to electric cars, can be communicated. That way the uncertainty of mainstream consumers could

be decreased, and the rate of adoption would rise, aiding a diffusion of electric cars. One of the consumers from the category early adopter states the following:

> *"I think information is an important factor. For example, I think what you are doing right now with this study is great and important. I hope this can spread so that the anxiety surrounding electric cars decreases a little. I think it's a lot about ignorance. For example, some say "you who live in the city can have an electric car, but we who live in the countryside cannot." I do not understand that at all. I think that statement is just about a lack of information. There are as many electrical outlets as possible out in the countryside. It is as easy as anything to charge at home. Then, of course, you have to have a certain range for it to work and also I think that charging in residential areas with condominiums, townhouse areas and such, can be a bit problematic… but there is a need for more spread of information." (EA3).*

> *"One does not exactly get overwhelmed with information, so you will probably have to look it up yourself if you want to gain knowledge about electric cars. I do not think there is a lot of advertising like that." (LM1).*

However, some of the respondents' experience is that just in the past couple of years, car producers have started both manufacturing and marketing electric cars to a larger extent than previously, which suggests that a transformation is starting to emerge where producers will adapt to a new system together with a simultaneous increased demand from consumers. The implications of producers beginning to adapt to the possibility of an electric vehicle fleet instead of the current fossil fuel fleet, is however dependent on both an increased consumer adoption of electric cars and a fast development of complementaries. Without a simultaneous advancement of complementaries, both the consumer and producer acceptance of the new norm will likely be undermined.

> *"I think a lot will happen now also because all the big car manufacturers like Volvo and Mercedes have electric cars now and it's a bit like a ketchup effect, I think. It will probably happen a lot in the coming years. Then it also depends on how the attitude becomes to other cars." (I2).*

Limited possibilities for proximity observation: Related to the lack of information communicated through the social system, is the limited possibilities for observing the innovation through connections to someone in one's proximate network. Electric cars are not yet diffused to the extent that most car consumers have somebody in their proximity that uses an EV, and the innovation can thus not easily be observed in reality through consumers' social circles. While some of the EV-users explain that they got curious to try an electric car due to the fact that someone close to them

had made a commitment to an EV, most of the respondents participating in the interviews state that they did not or do not know anybody who drives an EV. In addition, several of the EV-users stress the importance of test-driving an EV for their adoption decision. The results thus imply that it is vital for consumers to get an opportunity to try practical implementation of the innovation for them to adopt it. The limited observability of electric cars may therefore hinder the rate of adoption for mainstream consumers, which in a way creates a puzzle where the currently limited rate of adoption acts as a setback for further diffusion. Purchasing a vehicle is often a big decision, and more often than not, consumers test drive a car before committing to a purchase, regardless of what type of car it is. However, the currently dominating socio-technical regime, that is the fossil fuel fleet, offers considerably more observable information about ICE cars, which results in an uncertainty related to electric vehicles that requires substantially more convincing for mainstream consumers to make an adoption decision. This may result in a decreased willingness among car salesmen to direct consumers to electric vehicles, as the required effort to reduce the customers' uncertainty towards an electric car is larger than for an ICE car. One of the Innovators describes the following:

> *"Car dealers do not seem interested in pushing for electric cars. Not even when you ask about electric cars, they start talking about them, but they want to stick to the old. They have done surveys like this in Germany that someone went into a hundred different car dealers or something and it was over 50% of the car dealers who suggested that they should buy petrol or diesel even though they asked about electric cars when they came in. So that is a factor that slows down the spread of electric cars, I think. I believe that the car industry, manufacturers, sellers, must have a strong incentive to sell electric cars in order for advertising and information to reach out better. Then it is quite crucial what car salesmen say when you come to the car showroom, they argue for the benefits of electric cars, perhaps more people would have bought them."* (I1).

5. Discussion and concluding remarks

5.1 Discussion

This thesis aims to examine the possibilities and challenges for expanding the electric vehicle adoption in Sweden, focusing on theoretical concepts from the diffusion of innovation-framework (Rogers 1962; 2003). From the analysis of the main themes distinguished in the data collected from the interviews, the main possibilities and challenges for a more widespread consumer adoption of electric vehicles in Sweden, may be identified.

5.1.1 Possibilities

The findings show that environmental effects are considered a great benefit of driving an electric vehicle, both by consumer groups that have already adopted electric cars and consumers that have not. The general perception of positive environmental effects of driving an electric car may thus be seen as a possibility for diffusion as it is relatively superior to ICE vehicles in this respect. However, the findings also show that, while the electric car is consistent with many of the consumers' sustainability values, these values are much stronger for the consumers in the categories, innovator, early adopter and early majority. The environmental benefits are therefore more compatible with these consumers' values, and thus the environmental benefits of the innovation act as a much larger relative advantage for these consumers than the late majority-consumers and laggards. Moreover, the results show that several of the consumers find the lower cost for electricity relative to fossil fuel to be a relative advantage of electric cars. However, most of the consumers who voiced this opinion were EV drivers and many of the non-EV drivers do not seem to know about the relatively lower costs for fuel, or alternatively do not consider it a benefit. The reason behind the difference in the consumer groups could thus be a lack of information and knowledge, or simply that the lower fuel costs are negligible or overshadowed by the relatively higher purchasing price of electric cars, to these consumers. Nevertheless, the lower fuel cost in itself may be considered a possibility for an expanded consumer adoption as it is perceived as great benefits by consumers with knowledge about it. In the future, when the purchasing price for EVs will likely continue to decrease, the lower fuel costs may be expected to act as larger benefits to consumers that consider the price to be an overshadowing aspect. Furthermore, the social status related to electric vehicles is perceived as a beneficial factor by several of the consumers in the study, regardless of the consumer group. Nonetheless, while consumers that tend to accept new innovations early view the status factor as a bonus, it was not a determining factor for the decision to adopt, to these consumers. Most of the consumers in the categories innovator and early adopter describe that other factors such as their environmental values, were much more important than the status factor related to the car. However, apart from the laggard, the non-EV users generally consider the "coolness" of electric vehicles as a positive effect of the innovation, which implies

that the social status related to electric cars can be a possibility for electric vehicle adoption among these consumers.

5.1.2 Challenges

The empirical findings suggest that the price for purchasing or leasing an electric vehicle is one of the greatest obstacles for expanding the electric vehicle adoption. Both the EV users and the non-EV users perceive the relatively higher price for electric cars as a negative aspect. The difference is that the consumers who have already adopted an electric car perceive the benefits of the innovation as large enough to make up for the high price. Several of the EV-users also highlight that the financial benefits of the lower fuel costs make up for some of the financial disadvantages of the purchasing or leasing price. Nevertheless, the relatively higher price for electric cars may be a major challenge for achieving a more widespread consumer adoption. However, as several of the EV-users stated in the interviews, the purchasing prices for electric cars have decreased in the past few years as a result of the technological advancements, which may solve the problem of the price challenge in the near future. Another theme found in the data, that may be distinguished as a challenging factor, is the perception of the driving range of electric cars. The findings suggest that this is another of the largest worries for consumers who have yet to accept electric vehicles. The consumers' perception of the driving range of EVs as relatively worse than for ICE cars, is thus a large challenge for diffusion of electric cars. However, advancements in battery technology has led to major improvements in the driving range in just the last couple of years. Thus, this challenge may, similar to the price, decrease in importance in the coming future.

The infrastructure related to electric vehicles is another very important theme of the findings that may act as a major challenge for expanding the EV adoption in Sweden. Data from the interviews suggest that the charging system, the related payment methods and limited opportunities for home charging, needs to improve. The entire social system and infrastructure are to a great extent structured around the fossil fuel fleet and thus, one of the most important complementaries to the electric vehicle has not yet developed to the extent that it needs to. Furthermore, as more consumers begin to adopt electric cars, the pressure on the charging systems and infrastructure will increase which will further cause issues for the diffusion process. Thus, the infrastructure and general structure of the social system as built for a fossil fuel fleet, creates a substantial bottleneck effect that hinders the adoption of the innovation. While it seems likely that other obstacles such as the driving range or price will improve and consequently decrease in importance in the near future, the needed infrastructure may be a larger challenge if it does not develop rapidly enough as this will hinder the momentum and expansion of electric vehicle adoption. Therefore, the infrastructure related to the electric car may be the largest challenge when it comes to achieving an increased consumer adoption.

Another theme that can be identified as a challenge for increasing consumer adoption, is the perception of electric cars as a complex innovation by consumers that have not tried it. The findings also show that the possibilities for proximity observation are limited as the innovation has not yet spread to the extent that most mainstream consumers can observe the innovation within their social circle. This creates an uncertainty and a knowledge barrier that hinders the diffusion. Moreover, the non-EV drivers in the study implied that the effects and results of driving an electric car is fairly intangible which may further act as a challenge for increasing the electric vehicle adoption in Sweden. These aspects may be related to the insufficient access to information about electric vehicles. Most of the consumers in the study experience that the consumer themselves must make an effort to access information about EVs. It is evident that the consumers in the groups "innovator", "early adopter" and "early majority", who have already adopted electric vehicles, are more interested and susceptible to information about new innovations. These consumers tend to seek information themselves. The image that the non-EV-users have of most of the issues related to electric cars, seem to be tainted by a lack of information. After comparing the responses from both EV-users and non EV-users, it appears that perceived obstacles like price or driving range would not be as prominent if the information about these elements had a broader reach among mainstream consumers. For instance, few consumers have the need for a longer driving range in their everyday use than what an average electric car offers. Nevertheless, this is seen as one of the main reasons for not adopting an electric car among the non EV-users. The interviews showed that there is in fact no substantial resistance to electric cars among most ICE car-drivers, but the information and knowledge foundation for decision making is too scarce among mainstream consumers. Thus, a wider electric vehicle adoption will be dependent on aiding these consumers with information and knowledge in order to change the perception. This of course includes an effort from other stakeholders and decision makers.

5.2 Theoretical contribution

This thesis provides a qualitative insight into different consumer groups' perception of electric vehicles and the general automotive sector. The study contextualizes the diffusion of innovation framework by Rogers (1962; 2003) in the automotive sector and provides an understanding of the possibilities and challenges in expanding the electric vehicle adoption in Sweden through identification of the main themes in the different consumers' perceptions, opinions, and experiences. Previous literature has focused on either exclusively consumers with no experience of electric cars or exclusively consumers that have already adopted an electric car. This study shows the perspective of different consumer groups with the aim of providing a fair representation of the consumers within the industry and thereby increasing the transferability of the study. The thesis therefore contributes with an increased understanding of what is lacking for a diffusion of electric vehicles and what opportunities that can be exploited in order to increase the consumer adoption of electric vehicles and thereby move towards a sustainability transition of the Swedish automotive sector.

5.3 Practical implications

The findings of the thesis may provide insights for different stakeholders with an interest in the diffusion of electric vehicles. Practical implications of the findings may thus include decisions for producers, manufacturers and vehicle sales. Moreover, the findings may give an increased foundation of knowledge for decision makers that enforce regulations related to the different themes found in the study. Perhaps one of the most important findings is the importance of preventing the substantial bottleneck effect of the underdeveloped infrastructure related to electric vehicles, which provides policy implications for the government whose incentive to increase consumer adoption of electric cars is large. Another immensely important aspect is the need for a better distribution of information. It may be of interest for both producers and governmental actors to increase the spread of information in order to expand the electric vehicle adoption, and thereby come closer to a shift towards sustainability within the socio-technical regime.

5.4 Future research

The study was limited to a restricted sample size due to time constraints. Future research should thus include a larger sample of consumers from each consumer category in order to obtain even more transferability results of how consumers within the socio-technical regime in the automotive industry perceives, experiences and reacts to electric vehicles. Furthermore, because of the restrictions of this thesis, the study was limited to the consumer perspective. Future research may include the perspective of other stakeholders like producers, policy makers and political committees. By doing so, one may identify connections between the different actors in addition to the consumers' willingness to adapt to electric vehicles, and it would therefore be possible to analyze and draw conclusions about the different levels of the sociotechnical system and a possible future sustainability transition.

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Appendices

Appendix 1a: Interview Guide for EV users

- How old are you?
- Where do you live? (rural/urban/suburban)
- What is the brand/model of your car(s)?
- For how long have you been driving an EV?

Relative Advantage - The degree to which an innovation is seen as better than the idea, program, or product it replaces.

- *What made you switch from an internal combustion engine (ICE) vehicle to an EV?*
- *What would you say are the advantages with an EV?*
- *What is your experience of the range of the EV?*
- *Was the EV more expensive than previous cars you have purchased and is the EV worth the price, Why?*
- *To what extent would you say that you made the decision to purchase an EV due to status/coolness/desirability?*
- *What impacted you/made you think about switching to an EV?*
- *Will you purchase an EV the next time you will purchase a car?*

Compatibility - How consistent the innovation is with the values, experiences, and needs of the potential adopters.

- *To what extent would you say that the environmental benefits with an EV affected your purchasing decision?*
- *To what extent would you say that the EV meets your mobility needs?*

Complexity - How difficult the innovation is to understand and/or use.

- *Would you say that the EV is more difficult to use or understand than an ICE car?*
- *Are there any issues or obstacles for using the EV? What?*
- *How did you receive information about EVs prior to your purchase?*

Trialability - The extent to which the innovation can be tested or experimented with before a commitment to adopt is made.

- *Did you get a chance to "test use" an EV before you purchased it and what were your perceptions of that car during the test period?*

Observability - The extent to which the innovation provides tangible results.

- *Are there any positive differences related to your mobility and car usage after you decided to buy an electric vehicle?*

- *Are there any negative differences?*
- *How did you obtain information about EVs?*
- *To what extent have you observed EV usage by individuals in proximity to you?*

Appendix 1b: Interview guide for non-EV users

- How old are you?
- Where do you live? (rural/urban/suburban)
- What is the brand/model of your car(s)?

Relative Advantage - The degree to which an innovation is seen as better than the idea, program, or product it replaces.

- *Have you ever considered purchasing an EV and what made you not commit to a purchase?*
- *What do you think the advantages with EV could be?*
- *What would you say the main factors for not using an EV are?*
- *What are the benefits with an ICE car to you?*
- *Do you think that driving an EV adds status/coolness/desirability?*
- *To what extent does the price affect your decision to use an ICE car?*
- *What would it take for you to purchase an electric vehicle the nex time you buy a car?*
- *What are the most important factors that you consider when purchasing a new vehicle?*

Compatibility - How consistent the innovation is with the values, experiences, and needs of the potential adopters.

- *Are you aware of the environmental benefits of an EV?*
- *What is your perception of the driving range/battery range of an EV and to what extent would you say that the range of an EV has affected your decision to not use an EV?*

Complexity - How difficult the innovation is to understand and/or use.

- *Did you receive any information about EVs when you purchased your ICE?*
- *Do you think that EVs seem complex and difficult to use? How has this affected your decision to not get an EV?*
- *Do you consider it difficult to find and assimilate information about EVs and the pros and cons of EVs?*

Trialability - The extent to which the innovation can be tested or experimented with before a commitment to adopt is made.

- *Have you ever gotten the opportunity to test an EV?*
- *If not, would you like to try an electric vehicle?*

Observability - The extent to which the innovation provides tangible results.

- *Are you aware of the results of using an EV?*
- *What do you think are some positive effects of using an EV?*
- *What do you think are some negative effects of using an EV?*
- *Do you think that the information about EVs and their benefits are good enough? If not, what is missing?*
- *Is there anyone in proximity to you that has purchased an EV? If so, has this person(s) informed you about EVs?*

Appendix 1c Announcements to participants

Facebook group for electric car-drivers:

English translation: Hi! I am currently studying the last semester of a master's program in sustainable development and innovation at Lund University. In my thesis, I have chosen to investigate consumers' perceptions of electric cars and what factors are decisive in increasing the use of electric cars. Part of my study is based on interviews with users of electric cars. I am therefore wondering if anyone (who drives an electric car) would consider participating in an interview. The interview takes a maximum of 30 minutes and can of course be conducted by telephone / digitally. The answers will be anonymous. I would have been incredibly grateful if any of you could consider helping out with this study. It would be of great help to me in my studies and can hopefully also contribute to an increased awareness of the benefits of using an electric car. Write me a private message or comment below if you are interested. Thanks!

Swedish (original): Hej! Jag studerar just nu sista terminen på ett mastersprogram i hållbar utveckling och innovation vid Lunds universitet. I mitt examensarbete har jag valt att undersöka konsumenters uppfattning om elbilar och vilka faktorer som är avgörande för att öka användandet av elbilar. En del av min studie bygger på intervjuer med användare av elbilar. Jag undrar därför om det är någon (som kör en elbil) som skulle kunna tänka sig att ställa upp på en intervju. Intervjun tar max 30 minuter och kan självklart genomföras per telefon/digitalt. Svaren kommer vara anonyma. Jag hade varit otroligt tacksam om några av er skulle kunna tänka sig att ställa upp på detta. Det hade varit till stor hjälp för mig i mina studier och kan förhoppningsvis även bidra till en ökad medvetenhet om fördelarna med användandet av elbil. Skriv i PM eller kommentera nedan om ni är intresserade. Tack!

Facebook group for ICE car-drivers:

English translation: Hi! I am currently studying the last semester of a master's program in sustainable development and innovation at Lund University. In my thesis, I have chosen to investigate consumers' perceptions of electric cars and what factors are decisive in increasing the use of electric cars. Part of my study is based on interviews with users of internal combustion engine cars. I therefore wonder if there is anyone (who drives an ICE car) who could consider participating in an interview. The interview takes a maximum of 30 minutes and can of course be conducted over telephone / digitally. The answers will be anonymous. I would be incredibly grateful if any of you could consider helping out with this study. It would have been of great help. Write me a private message or comment below if you are interested. Thanks!

Swedish (original): Hej! Jag studerar just nu sista terminen på ett mastersprogram i hållbar utveckling och innovation vid Lunds universitet. I mitt examensarbete har jag valt att undersöka konsumenters uppfattning om elbilar och vilka faktorer som är avgörande för att öka användandet av elbilar. En del av min studie bygger på intervjuer med användare av fossildrivna bilar. Jag undrar därför om det är någon (som kör en fossildriven bil) som skulle kunna tänka sig att ställa upp på en intervju. Intervjun tar max 30 minuter och kan självklart genomföras per telefon/digitalt. Svaren kommer vara anonyma. Jag hade varit otroligt tacksam om några av er skulle kunna tänka sig att ställa upp på detta. Det hade varit till stor hjälp för mig i mina studier. Skriv i PM eller kommentera nedan om ni är intresserade. Tack!