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BARRIERS TO ELECTRIC VEHICLE ADOPTION IN FINLAND AND HOW TO OVERCOME THEM: AN ANALYSIS OF CONSUMER OPINIONS AND PERCEPTIONS

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ABSTRACT OF
BACHELOR'S THESIS

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Objectives

The main objective of this study was to explore consumer opinions and perceptions regarding EVs and EV incentive policies in Finland in order to better understand how adoption rates could be increased.

Summary

A qualitative online survey was conducted within Finland with 71 respondents, most of which were Finnish students. Respondents were mainly asked to indicate their level of knowledge and experience with EVs, to rate different benefits and drawbacks of EVs, and to rate the appeal of different policy incentives for increasing EV adoption rates in Finland.

Conclusions

The results indicated that while aspects like high purchase price and range constraints are considered severe limitations for EV adoption, the most severe limitation currently is a lack of charging infrastructure in Finland. The results also highlight the need for consumer education regarding EVs in Finland as both OEMs and the government stand to benefit by better informing consumers.

Key words: electric vehicles, battery electric vehicles, consumer behaviour, consumer opinions, incentive policies, Finland

Language: English

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LIST OF ACRONYMS

Acronym	Definition	Explanation
AFV	Alternative Fuel Vehicle	A vehicle that is powered by an alternative fuel source to fossil fuels, such as electricity, biofuels, or hydrogen.
BEV	Battery Electric Vehicle	A fully electric vehicle with zero tailpipe emissions that is powered by an electric drivetrain featuring an internal battery pack and electric motor/s.
CO2	Carbon Dioxide	The main greenhouse gas emitted by the transportation sector.
EPA	Environmental Protection Agency	A US government agency that is responsible for environmental protection. It also gives EVs range ratings based on testing procedures.
EV	Electric Vehicle	An umbrella term to describe all vehicles featuring an electric motor including fully electric vehicles and hybrid vehicles. Sometimes used interchangeably with BEV.
GHG	Greenhouse Gas	A gas that absorbs and emits radiant energy within the thermal infrared range causing the greenhouse effect warming surface temperatures on earth. Carbon dioxide, water vapor, methane, nitrous oxide, and ozone are the primary greenhouse gases in Earth's atmosphere.
HEV	Hybrid Electric Vehicle	A vehicle featuring an internal combustion engine, battery pack and electric motor. The battery pack is charged by storing energy from regenerative braking and the internal combustion engine. HEVs can run on two fuel sources, namely electricity and gasoline or diesel.
ICEV	Internal Combustion Engine Vehicle	A vehicle powered by the combustion of fossil fuels, such as gasoline or diesel, within the engine of the vehicle.

IDT	Innovations Diffusions Theory	A theory proposed by Rogers (1962) that explains how a product gains momentum in society and diffuses or spreads among the population.
OEM	Original Equipment Manufacturer	E.g. Tesla, BMW, Toyota, etc.
PHEV	Plug-in Hybrid Electric Vehicle	A vehicle featuring an internal combustion engine, battery pack and electric motor. The battery pack is charged by plugging the vehicle to an external power source hence the name Plug-in Hybrid Electric Vehicle. PHEVs can run on two fuel sources, namely electricity and gasoline or diesel.
TAM	Technology Acceptance Model	A theory proposed by Davis (1989) that attempts to predict how technological products are adopted.
TCO	Total Cost of Ownership	A method of calculating the true cost of owning a product by taking into consideration the cost associated with the acquisition, possession, use, and subsequent disposal of that product.
TPB	Theory of Planned Behaviour	A theory proposed by Ajzen (1991) used to predict human social behavior.
V2G	Vehicle-to-grid	The ability of an EV to return electricity to the power grid or throttle the rate of charge.
WLTP	Worldwide Harmonised Light Vehicles Test Procedure	The new testing procedure adopted in the EU in 2017 used for determining the levels of pollutants, CO_2 emissions and fuel consumption of ICEV and hybrid cars, as well as the range of BEVs.
WTA	Willingness to Accept	The degree to which a consumer is willing to accept a good or service.

WTP	Willingness to Pay	The degree to which a consumer is willing to pay for a good or service.
ZEV	Zero Emission Vehicle	A vehicle that emits zero tailpipe emissions such as BEVs.

1. INTRODUCTION

1.1. Background

In recent years, the global automobile industry has been going through a fundamental change with new megatrends taking over the industry, such as electrification, autonomous driving, the increased importance of connectivity in the driving experience, as well as new alternatives to private car ownership such as the rise of mobility-as-a-service companies like Uber (Sull & Reavis, 2019). Interest in EVs has increased dramatically as emissions standards have forced manufacturers to explore alternative fuel sources, charging infrastructure has improved substantially globally, and competition has forced manufacturers to innovate outside the conventional ICEV market (Marketline, 2019). As battery technology has improved, EVs have been touted as a viable alternative to conventional ICEVs with the benefit of being environmentally friendly. A market that was almost non-existent a decade ago is now growing rapidly with the global market share of EVs expected to reach approximately 15% by 2030 up from just 1% in 2018 (International Energy Agency, 2019).

In 2018 the EV market share in Finland was 4,7% (International Energy Agency, 2019). Globally, this figure is among the highest in the world, but with the exception of Denmark, Finland lags behind its Nordic neighbors when it comes to EV adoption with Sweden sitting at 7,9%, Iceland at 17,2%, and Norway at 46,4% in 2018 (ibid). However, Finland's EV market has been growing rapidly in recent years with a growth rate of 51,8% in 2018, although notably hybrid vehicles make up more than

95% of the EV market in Finland (MarketLine, 2019) compared to Norway where BEVs account for 51,8% of the market's total volume (MarketLine, 2019). This means than BEVs only comprise 0,5% of the entire car market in Finland (VTT Research, 2017).

From an environmental perspective, the deployment of EVs in Finland makes sense due to the nature of Finnish energy production. The energy sector accounts for 75% of GHG emissions in Finland of which energy production at 44% and transport at 27% are the main components (Statistics Finland, 2019). However, an unprecedented 82% of electricity production in Finland in 2019 was produced emissions-free illustrating the effectiveness of cap-and-trade policies within the EU (Finnish Energy, 2019). Nuclear energy accounted for 35% of domestic electricity production, hydropower for 19%, and biomass for 18% (ibid). Wind power is also expected to grow rapidly within Finland providing a large share of the electricity for EVs by 2030 as the role of coal will gradually decline (Hedegaard et al., 2012).

The Finnish government has set ambitious environmental targets pledging to achieve carbon neutrality by 2035 by disincentivizing and phasing out the use of dirty energy sources like coal and peat (Finnish Government, n.d.). Regarding EVs specifically, Finland has set a goal of 250 000 BEVs by 2030 but also incentivizes the use of biofuels heavily with a target of 50 000 vehicles by 2030 (Nikula, 2016). It is important to note that even though the adoption of EVs and BEVs in particular in Finland will be insignificant in the early stages of the 2020s and will likely only achieve mass adoption by the 2030s, these measures aren't necessary to reach Finland's emissions targets as a whole (Nylund, 2011; Raiskio 2018). Nonetheless, the adoption of EVs will play an important role in the de-carbonization of the transport sector in Finland in the future and therefore increasing adoption rates will be important.

1.2. Research Problem

In order for EVs to become mainstream and commercially successful, consumer acceptance is of vital importance. Even though EVs have made remarkable improvements over the past decade they still face numerous limitations, which will be discussed in this paper. Within Finland, the adoption of EVs and BEVs more specifically has lagged behind other Nordic countries despite recent government efforts. This is a problem, as the adoption of EVs is an effective way of reducing GHG emissions as well as air pollution. Therefore, the research problem presented in this research paper is the low adoption rates of EVs and most notably BEVs in Finland. This leads to the obvious question of how adoption rates could be increased which is the focus of this study.

1.3. Research Questions

1. What are the main barriers to the adoption of electric vehicles in Finland?
2. What incentives will be practical and effective in increasing EV adoption rates?

1.4. Research Objectives

1. To understand consumer attitudes and opinions regarding EVs in Finland.
2. Compare the primary data that is collected from this study with findings from previous research.
3. To understand the key measures that need to be put in place to increase EV adoption rates in Finland.

2. LITERATURE REVIEW

2.1. Introduction

The literature on EVs has grown rapidly in recent years as has the prominence of EVs in general. However, much of the research to date has been focused on the technological aspects of EVs and less so on consumer perceptions and preferences (Larson et al, 2014; Graham-Rowe et al, 2012; Adnan et al., 2016). Consumer intentions to adopt EVs can be broadly categorized as a mixture of demographic, situational, and psychological factors (Li et al, 2017). Some of the major situational concerns with EVs from a consumer perspective are range, cost, and charging constraints (Egbue & Long, 2012; Li et al., 2017). In order to limit the scope of this literature review, only these major barriers to adoption will be covered. Specifically, price and total cost of ownership will be covered as well as concerns regarding range and charging infrastructure.

From the perspective of an individual consumer, an EV must satisfy their personal requirements and be considered a better alternative to an ICEV to justify adoption. This depends on the consumer's personal levels of intrinsic motivation for adoption, meaning the degree to which they value different characteristics of the vehicle, and extrinsic motivation, which is stimulated by rewarding adoption and is therefore guided by government policy (Langbroek et al., 2016). A theory that can be used to analyze EV buying behavior is the Theory of Planned Behaviour as proposed by Ajzen (1991), which is one of the most cited theories for the prediction of human social behavior. This theoretical model is based on an individual's attitude towards behavior, subjective norms, and perceived behavioral control (Tu & Yang, 2019). In the case of an EV, adoption behavior is explained by how a consumer views the vehicle, how they perceive others to view the vehicle, and how easy or hard it is for them to operate the vehicle. Furthermore, the purchase of an EV can be characterized as complex buying behavior because consumer involvement is high and the perceived differences between brands are also significant (Munthiu, 2009).

Two other theoretical models that can be used to analyze EV adoption behavior are the Technology Acceptance Model (TAM) proposed by Davis in 1989 and the Innovations Diffusion Theory (IDT) proposed by Rogers in 1962 (Tu & Yang, 2019). This is due to the fact that the EVs can be considered to be technologically advanced and innovative products that are just entering the growth stage of the product life cycle. These theories attempt to explain how innovative or technological products are adopted and why they can face resistance to adoption. According to the TAM, an individual's intention to use technology is influenced by perceived ease of use and perceived usefulness (Davis, 1989). IDT, on the other hand, explains how a product gains momentum in society and diffuses or spreads among the population (Rogers, 1962). According to the theory, adoption intentions are influenced by the relative advantage, compatibility, complexity, trialability, and observability of a product (ibid). Furthermore, Rogers (1962) proposed that consumers could be segmented into adopter categories, namely innovators, early adopters, the early majority, the late majority, and laggards.

This literature review has been organized in the following way. A brief introduction to the history of EVs is included at the start of the literature review because it provides insights into how EV technology has developed and why only in recent years have EVs become a viable alternative to ICEVs. This is followed by a section discussing the environmental impact of EVs. After this, the major barriers to EV adoption identified in the literature will be discussed. A section analyzing studies within Finland has been included to provide a deeper understanding of how Finnish consumers view EVs and what kind of barriers to adoption are specific to Finland. This is a major limitation in the current research, considering the scarce amount of research that has been conducted within Finland and will, therefore, be the focus of this research paper.

A section on the effectiveness of different policy measures and financial incentives has also been included. Norway, the global leader in electric mobility, has been chosen as an example of successful policy implementation. Finally, a conceptual framework is presented which pertains to the research questions presented in this research paper. The conceptual framework has been developed based on previous research findings.

2.2. A Brief History of EV Development

Electric vehicles, or EVs as they are commonly known, have reemerged in the past decade as a viable alternative to conventional ICEVs. In fact, the first EVs were developed during the 1800s, predating conventional gasoline cars when horseback riding was still the main form of transportation (Department of Energy, 2014). In the early 1800s, innovations in battery technology were made, such as the ability to store electricity chemically and the discovery of electromagnetic conduction, which lead to the first electric motor (Hoyer, 2008). Between 1880-1920, further electrochemical innovations followed, such as the discovery of regenerative braking and hybrid technology, which are still relevant today (ibid).

As EVs reached the height of their popularity at the beginning of the 20th century in the US, competition from gasoline-powered cars grew, such as the considerably cheaper Ford T-model introduced in 1908, ultimately leading to the demise of EV development (Department of Energy, 2014). Gasoline-powered ICEVs had some distinct advantages over EVs at the time besides the cost advantage, some of which are still relevant today to a lesser degree. Firstly, EVs had a very limited range, and as the road network within the US improved, people wanted to travel further distances and ICEVs met this demand (Lixin Situ, 2009). Furthermore, the discovery of vast amounts of cheap oil in the 1930s made ICEVs more convenient as charging infrastructure was very underdeveloped compared to the rapidly increasing network of gasoline stations with gasoline possessing the added benefit of being easy to transport (Anderson & Anderson, 2010).

Between 1920-1970 EV development was at a standstill, with the Great Depression in the 1930s and later World War II hampering interest in the area (Anderson & Anderson, 2010). In the early 1970s, interest in AFVs grew as oil prices soared and shortages grew, which lead some automakers to develop EV prototypes, and later in the 1990s environmental concerns lead to emissions regulations being introduced forcing auto manufacturers to put an emphasis on fuel efficiency (Department of Energy, 2014). Some of the first mass-market HEVs were introduced such as the Toyota Prius and Honda Insight, later followed by the introduction of the Tesla

Roadster in 2006, the first fully electric production car to travel over 200 miles or 322 kilometers (ibid).

2.3. The Environmental Impact of EVs

Anthropogenic GHG emissions have continued to increase ever since the pre-industrial era with economic and population growth being the two main drivers of CO2 emissions from fossil fuel combustion globally (Pachauri & Meyer, 2014). These increases in GHG emissions have subsequently been a major contributing factor to climate change. Transportation is a major contributor to global GHG emissions accounting for 24% of direct CO2 emissions from fuel combustion globally (International Energy Agency, 2019). Furthermore, without adequate mitigation measures, GHG emissions from the transport sector could increase at a faster rate than from any other energy end-use sector highlighting the need for de-carbonization (Sims et al., 2014). The effect of road transport is of particular concern. Within the EU alone, road transport accounts for 82% of total GHG emissions from the transport sector, despite technological advancements and policy measures to limit emissions (European Environmental Agency, 2018). Within Finland specifically, transportation as a whole accounted for 21% of total GHG emissions of which road transport contributed 94% of emissions (Statistics Finland, 2019). Therefore, reducing emissions from road transport specifically can have a sizable effect on Finland's GHG emissions.

In order to limit GHG emissions from the transport sector, there are four general mitigation strategies: reducing reliance on carbon-intensive fuels, improving the energy efficiency of vehicles, reducing total demand for transportation, and changing modes of transportation (Bongart et al. 2013). Therefore, the adoption and advancement of alternative fuel sources to fossil fuels will be crucial in the de-carbonization of the transport sector (Offer et al., 2017; Wanitschke & Hoffman, 2019). In particular, EVs have reemerged in the past decade as a viable alternative to ICEVs with the promise of lowering GHG emissions. However, it is important to note that the adoption of EVs has other benefits too, such as reduced air pollution in urban areas which has consequences on human health (Casals et al., 2016). Noise pollution caused by transport is another health concern that has been shown to have severe adverse effects on human health (Murphy & Faulkner, 2018).

Furthermore, it is important to keep in mind that even though the eco-friendliness of EVs is often touted as one of the main benefits, the carbon footprint of an EV is determined by the means of energy production in each country. BEVs, in particular, are promising due to the fact that they emit zero-tailpipe emissions. In countries with a high ratio of nuclear or renewable energy production like Finland, BEVs are significantly more environmentally friendly than ICEVs, but in countries with significant reliance on fossil fuels, such as coal and oil, BEVs emit only marginally less CO2 than ICEVs (Athanasopoulou et al., 2018). Therefore, the eco-friendliness of EV deployment can differ greatly from country to country based on the forms of energy production. The decarbonization of electric grids across the globe along with improved battery recycling and re-use will be important factors in reducing the environmental impact of EVs (Hall & Lutsey, 2018).

Another important consideration when it comes to EVs and their environmental impact is that the production of EVs produces substantially more CO2 emissions than the production of ICEVs mainly due to emissions relating to the production of lithium-ion batteries and other electrical components. In a comparative study in China Qiao et al. (2017) found that the production of a typical BEV in China produced 60% more CO2 emissions compared to an ICEV. However, production emissions in Europe and the US are much lower and by adopting more efficient manufacturing techniques China could cut CO2 emissions by up to 66% (ibid). Furthermore, in 2018 the International Council on Clean Transportation released a report looking at production and life cycle emissions and concluded the following: ‘‘*We find that a typical electric car today produces just half of the greenhouse gas emissions of an average European passenger car. Furthermore, an electric car using average European electricity is almost 30% cleaner over its life cycle compared to even the most efficient internal combustion engine vehicle on the market today’’* (Hall & Lutsey, 2018).

2.4. Price and Total Cost of Ownership

One of the main barriers to widespread EV adoption identified in the literature is the comparably high price of EVs in relation to their ICEV counterparts. In fact, most OEMs don’t profit from the sale of their EV models, other than high-end offerings, because the manufacturing costs of a typical EV in the small- to midsize-car segment and the small-utility-vehicle segment is approximately $12,000 more than that of a similar ICEV alternative (Baik et al., 2019). This is also a problem at the dealership level. Zarazue de Rubens et al. (2018) studied dealerships in the Nordic countries and noted that dealerships don’t have a strong incentive to sell EVs because they are less profitable, due to the fact that they require additional investments by the dealership, such as personnel training, and they also bring in less after-sale revenue in the form of maintenance costs and other services. This makes the market penetration of EVs more difficult because OEMs and dealerships play an important role in promoting the adoption of EVs.

Nonetheless, the price differential between EVs and ICEVs currently is largely explained by the cost of batteries, which make up approximately 50% of the cost of a typical EV (Statista, 2019). However, looking at the overall electrification cost may be a better metric because it accounts for other costs such as electric motors, power electronics and research and development (Safari, 2018). Safari (2018) concluded that the electrification cost accounted for approximately 50% of the price of BEVs, with battery cost accounting for approximately 20% of the total vehicle price. Nevertheless, the price of battery packs has declined substantially over the past decade. Battery pack prices have fallen by 87% in real terms between 2010 and 2019 from over $1,100 to just $156 per kWh currently with prices expected to fall below $100 by 2024 (BloombergNEF, 2019). This reduction in price has been accomplished due to improved battery technology, mainly an increase in the energy density of battery packs, as well as the cost-savings brought by economies of scale (ibid).

The price range of $100 to $150 per kWh is a threshold that is widely considered to be the point where EVs will achieve price parity with ICEVs (Nykvist & Nilsson, 2015a). However, after analyzing empirical data on BEV prices and battery capabilities (Nykvist et al., 2019) found that even levels of $200 to $250 per kWh would be sufficient to produce an average priced vehicle with 200 miles or 320 kilometers of range, a level which has likely already been reached by manufacturers. Furthermore, the authors argue that models in more expensive market segments can drive down costs for more affordable segments effectively subsidizing the research and development costs. This closely resembles the strategy of Tesla, which is described in a blog post written by Elon Musk in 2006 as the following: *''The strategy of Tesla is to enter at the high end of the market, where customers are prepared to pay a premium, and then drive down market as fast as possible to higher unit volume and lower prices with each successive model.''*

Due to the price premium carried by EVs currently, Seixas et al. (2015) found that EVs would only become cost-competitive by 2030 within the EU if prices decreased by 30%. Moreover, the authors found that EU climate policy targets could play a major role in increasing adoption rates independent of prices. Similarly, Wolfram & Lutsey (2016) found that EVs would reach price parity with ICEVs by 2030 within the EU or potentially be more affordable than ICEVs due to cost reductions of 50-70% in EV powertrains. However, it is important to note that EVs enjoy some distinct advantages over ICEVs when it comes to costs. Even though EVs have substantially higher upfront costs due to higher purchase prices, in-use ownership costs are generally lower due to two main factors. Firstly, the electricity cost of operating an EV is substantially lower than that of an ICEV over the same distance, and secondly, EVs typically have lower maintenance costs than their ICEV counterparts (Brennan & Barder, 2016).

Therefore, focusing on the total cost of ownership rather than purchasing prices may be a more relevant metric. TCO analysis is a tool that can be used to understand the true cost of ownership of a product or service by taking into consideration the cost associated with the acquisition, possession, use and subsequent disposal of that good or service (Ellram, 1995). Multiple studies in recent years have been conducted to determine whether EVs are cost-competitive with ICEVs when ownership costs are accounted for. It is important to keep in mind that analyzing the total ownership costs of a vehicle is a lot harder to estimate than purchasing cost because TCO relies on assumptions regarding fuel costs, usage levels, maintenance costs, tax incentives, and depreciation among other variables.

Nevertheless, Weldon et al. (2018) analyzed the cost of ownership over a 10-year period and concluded that EVs were competitive under certain conditions. Specifically, larger more expensive EVs were more cost-competitive than smaller vehicles and that usage levels greatly affected the economic viability of EVs with higher usage levels favoring EVs over ICEVs. The authors noted that this was due to the cost savings from electricity as compared to gasoline as well as savings on long-term maintenance and repair costs. However, Brennan & Barder (2016) reached the opposite conclusion in an analysis of the 20-year cost of ownership of an EV stating that even when possible cost savings are taken into consideration the total cost of ownership of an EV is still 44% greater than that of an ICEV. However, it is important to note that Brennan & Barder (2016) didn't take government tax subsidies and other incentives into consideration in their analysis which highlights the importance of policy incentives when it comes to electric mobility.

The literature on consumer opinions regarding EVs indicates that consumers put more emphasis on upfront costs, specifically purchasing prices, rather than operating costs (Larson et al., 2014; Rezvani et al., 2015). This is due to the fact that the high acquisition costs associated with EVs and uncertainty regarding operating costs deter consumers from purchasing EVs even though they are generally viewed positively (Bühne et al, 2015). (Saccani et al., 2017) point out that even though TCO analysis is common in business-to-business settings it hasn't received the same level of attention in business-to-consumer settings. This indicates that analyzing TCO is difficult for consumers, which may explain why consumers discount TCO and fixate on purchase prices. This was also illustrated by Hagman et al. (2016) who found that EVs could be competitive with ICEVs when operating costs were accounted for but concluded that even when provided with this information consumers do not place much emphasis on operating costs. Dumortier et al. (2015) also found that even when consumers were provided with information on 5-year fuel savings, this didn't affect how consumers ranked different vehicles. However, providing consumers with information regarding the total cost of ownership of vehicles did make a statistically significant difference (ibid). This would indicate that providing consumers TCO information can be useful but consumers need to be made aware of potential savings.

However, two important factors consumers need to account for when considering an EV are resale value and battery degradation. These aspects aren't always taken into consideration when the TCO of an EV is analyzed because re-sale value doesn't directly influence ownership costs. In a recent analysis, research firm iSeeCars found that after 3 years of ownership EVs lost 56,6% of their value on average compared to 38,2% for all vehicles with only Teslas holding their value exceptionally well (Blackley, 2019). This rapid decline in resale value is largely explained by battery degradation or the reduced range of an EV after a few years of ownership. Battery degradation is a complex non-linear process that is affected by factors such as the number of charging cycles, temperature, charging speed and the state of charge (Buchmann, 2019). Specifically, EV owners are encouraged to only charge vehicles 80% full and deplete batteries to 20% full to extend battery life (ibid). However, data from 350 Tesla vehicles indicates that the typical vehicle only loses 5% of charge capacity after 100 000 km and 10% after 300 000 km, albeit this is better than most manufacturers (Lambert, 2018). Furthermore, most manufacturers give generous warranties for batteries with an 8-year or 160 000 km warranty being the norm (Buchmann, 2019).

2.5. Range Anxiety and Charging Constraints

Another common concern regarding EVs identified in the literature is the issue of limited range leading to range stress, commonly known as 'range anxiety', which refers to the fear that an EV will have insufficient range to reach its destination. Research indicates that consumers consider range constraints to be one of the main drawbacks of electric vehicles (Egbue & Long, 2012; Gyimesi & Visvanathan, 2011). However, range limitations only seem to be a major concern among inexperienced EV drivers (Franke et al, 2012); Franke et al, 2014; Yuan et al, 2018). This is to be expected as research indicates that when consumers gain experience with BEVs they have fewer concerns and realize more of the advantages leading to a more favorable view in general (Schmalfuß et al., 2017). Franke et al (2012) found that when consumers gained experience driving EVs range became less of an issue and consumers were able to successfully adapt the range capabilities of an EV to their own transportation requirements. Furthermore, the authors concluded that providing users a reliable usable range was more important than enhancing the maximum range of a vehicle and psychological barriers could be lowered through information, training, and interface design (ibid).

Therefore, considering that battery capacity is the main determinant of an EV's range, which adds cost and weight to the vehicle, simply increasing the size of the battery pack isn't the most optimal solution for all users but rather consumers should choose a vehicle based on their own transportation requirements (Mruzek et al., 2016). Furthermore, Pearre et al. (2011) discovered that OEMs didn't have a sufficient understanding of how consumers use ICEVs currently in terms of EV relevant criteria and concluded that segmenting consumers by range needs to be a more cost-effective strategy than assuming all buyers need large batteries and long-range vehicles.

In a study conducted in 2014, Franke et al. compared experienced BEV motorists with people with no prior experience and found that experienced drivers reported less range anxiety and BEV driving experience (defined as absolute kilometers driven) seemed to predict lower levels of range anxiety. In addition to driving experience, Yuan et al. (2018) discovered that resistance to emotions lead to lower perceived levels of range anxiety and increased the safety buffer drivers left themselves while driving. Other research also indicates that individual personality traits, such as tolerance for ambiguity, and coping skills, such as range practice, play a major role in perceived range anxiety (Franke et al., 2012).

Another interesting finding supported by the literature is that EVs can already satisfy the daily travel requirements of most people (Pearre et al., 2011; Needell et al., 2016; Mellinger et al., 2018) This would explain why experience with driving EVs lowers perceived range anxiety. This effect is especially apparent in metropolitan areas where travel distances are shorter and the charging infrastructure is more developed. For example, Franke & Krems (2013) carried out a 6-month field study in the metropolitan area of Berlin and found that users charged their vehicles on average three times per week, drove an average of 38 kilometers per day, and typically had a large surplus at the end of the day. It is important to note that participants in the study had access to a network of 50 public charging stations and had a private home-based charging station as well. Similarly, Needell et al. (2016) used information from travel surveys and GPS data to estimate energy requirements and found that BEVs could replace 87% of vehicles driven in the US on any given day with cities being especially suited for early BEV adoption.

It is important to note that EV range ratings are determined under different standards which can lead to discrepancies in different geographical areas. In 2017 the EU changed its rating standard to the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) because the old standard was considered inaccurate and outdated (European Automobiles Manufacturers Association, 2017). On the other hand, the EPA is responsible for rating EVs within the US and their test puts greater emphasis on highway driving than other testing procedures (Gaton, 2019). The way information is displayed to consumers can also affect levels of range anxiety with some evidence indicating that highlighting ambiguity in estimated mileage can make drivers calmer, less focused on range, and encourage adaptive driving rather than if the driver is lead to believe the information is precise and accurate (Jung et al., 2015). On the other hand, Franke et al. (2016) found that trust in the range estimation system, system knowledge, and route familiarity along with emotional stability lead to lower range anxiety when participants were faced with a critical range situation meaning they had a small range buffer.

The development of charging infrastructure and improving charging speed are two other aspects that can directly lower range anxiety. Refueling times specifically have been shown to determine preferences for EVs in addition to driving range (Hoen & Koetse, 2014). Considering that it can take up to 8 hours to charge a BEV battery depending on the size under normal conditions, the development of fast charging solutions that can charge batteries 50-80% full in 15-30 minutes will greatly enhance the viability of BEVs (Zhongqiao et al., 2015). This highlights the importance of developing fast-charging infrastructure while also considering optimal locations based on travel patterns and routes.

Furthermore, Raiskio (2018) points out that heavy EV deployment can put stress on the power grid especially during day times when basic electricity needs are also elevated. Therefore, the development of smart charging systems and vehicle-to-grid capabilities can enhance EV adoption. However, in a survey conducted in 2019, Noel at al. found that in the Nordic countries 90% of respondents didn't know what V2G was and only respondents in Finland and Norway valued the capability. Charging behavior can also be influenced by different policy incentives. Considering the rate of charge of an EV diminishes with time, Motoaki & Shirk (2017) found that a flat-rate fee incentivized EV owners to spend more time than necessary at fast-charging stations increasing the inefficiency of charging station use. However, the development of home charging stations has been shown to increase EV sales more than the development of work or public infrastructure which shows how EV refueling behavior differs greatly from ICEVs (Lin & Greene, 2011).

2.6. Consumer Opinions in Finland and Barriers to Adoption

Research studying barriers to the adoption of EVs in Finland has grown in recent years but is still fairly limited compared to the research that has been done in other countries or regions. In 2017, Finnish Energy company Fortum in partnership with market research firm Kantar TNS carried out a survey to investigate Finnish consumers' attitudes towards EVs with 1152 participants and a representative sample of the Finnish population (Fortum, 2017). The results from the survey indicated that 36% of Finns would be willing to buy a BEV if it could be charged at home and 30% if the charging infrastructure improved in a meaningful way. However, 22% of respondents said they wouldn't even consider buying an EV because they didn't know where to charge the vehicle. Respondents were also asked whether they believed they would own a BEV after 2 years (4%), 5 years (10%), and 10 years (18%) (ibid).

Even though the literature on EVs clearly indicates that range, charging speed, and charging infrastructure are major barriers to EV adoption generally, people in the Nordic region, including Finland, seem to put an increased emphasis on these practicality related attributes over performance (Noel et al., 2019). In a recent study by Mattila (2019), where the customer base of Skoda Finland was surveyed, the majority of respondents expected a range of 400-500 kilometers, even though the vast majority drove under 100 kilometers per day. This would indicate that consumers' expectations regarding EVs are based on experience with ICEVs rather than real-life requirements. Mellinger et al. (2018) also found that BEVs could cover between 85-90% of journeys within Finland in 2017 and with infrastructure policies in place BEVs could cover 99% of journeys. The charging infrastructure within Finland has in fact started to improve within recent years although more efforts are needed. In 2019, there was a total of 1025 public charging stations in Finland of which 319 were capable of fast charging (>22kW) up from 197 in 2018 (European Alternative Fuels Observatory, 2019).

A typical BEV in 2017 had an average rated range of 181 miles or 291 kilometers, but this figure is increasing continuously as manufactures are increasing battery capacities (Shell, 2017). However, the range of an EV can be greatly affected by external factors such as outdoor temperature, the weight of the vehicle, driving style, headwinds, high-speed driving and elevation changes (Environmental Protection Agency, 2018). An important consideration in Finland is the climate. Finland has 4 distinct seasons with temperatures dropping well below 0 degrees Celsius in many parts of the country during the winter (Finnish Meteorological Institute, n.d.). Cold temperatures have been shown to have two main negative effects, namely performance loss and battery degradation, highlighting the importance for OEMs to implement thermal management systems (Jaguemont et al., 2016).

Furthermore, battery range efficiency is maximized at approximately 20 degrees Celcius, and charging speed is also affected by a decrease of 15% at -10 degrees Celcius (Lindgren & Lund, 2016). Moreover, in a recent study in Finland, a temperature of -11 degrees Celsius led to an average decrease in range of 32% as compared to the official WLTP rating among tested BEVs (Linja-Aho, 2019). This is an important consideration, specifically in northern Finland, where the charging infrastructure is less developed and temperatures can go below 20 degrees Celcius in the winter, which also speeds up the battery degradation process limiting range even more (Viinikka, 2020). Range concerns and charging infrastructure constraints may, therefore, explain the popularity of hybrid vehicles relative to BEVs in Finland.

Some studies have also attempted to examine demographic factors within Finland regarding attitudes towards EVs. A clear and unsurprising finding is that people in urban areas are more receptive to EVs (Nyberg, 2018; Mattila 2019). However, surprisingly even though people living in metropolitan areas are better suited for EV adoption Zarazua de Rubens et al. (2018) found that urban car dealerships in Finland were comparatively worse at promoting and selling EVs than rural-based dealers, even though urban dealerships have vehicles readily available, superior infrastructure and the certified expertise to sell EVs. This highlights the fact that dealerships don’t have a strong incentive to sell EVs as ICEVs are more profitable currently.

Other factors that seem to influence EV adoption positively within Finland are income level, education level, and the number of children in a family (Saarenpää et al., 2013). However, in a study analyzing 30 different countries, Sierzchula et al. (2014) found that socio-demographic factors such as income, education level, and environmentalism were not good predictors of EV adoption levels generally, but this finding may be explained by the relative size of national EV markets. Nonetheless, according to Mattila (2019), within Finland men seem to be more open to buying BEVs and put a greater emphasis on technological attributes whereas women value the eco-friendliness of BEVs more. Interestingly, in study surveying EV owners in Sweden, Vassileva & Campillo (2017) observed no differences in motivating factors for adopting EVs between the genders, so the literature is inconclusive.

2.7. Policy Recommendations and Financial Incentives

Due to the constraints currently facing EVs, such as the high purchase price relative to ICEVS, and range concerns of consumers, strong policy support and incentives are needed (Safari, 2018; Nykvist et al., 2019; Weiss et al., 2012). Although some policies, such as financial incentives and improving charging infrastructure have been shown to increase adoption rates universally (Sierzchula et al., 2014), in order to increase adoption rates in Finland specifically, these policies need to be tailored to the Finnish market. It is important to note that at an individual level, the willingness to adopt EVs is determined by the intrinsic and extrinsic motivation of a consumer with intrinsic motivation referring to the degree to which a consumer values the characteristics of an EV such as design, acceleration, or range, whereas extrinsic motivation is stimulated by policy incentives because they attempt to lower the costs of EVs (Langbroek et al. 2016). Therefore, individual consumers may respond differently to policy proposals.

Nonetheless, examining Norway may be the most useful way of determining effective policy incentives due to the fact that Norway is the global leader in electric mobility with BEVs alone accounting for 42% of new car sales in 2019 fueled by strong sales of the Tesla Model 3 (Holter, 2020). Ironically, Norway has also set itself an ambitious target of ending the sale of fossil fuel-powered cars by 2025, even though the country is Europe’s biggest oil and gas producer (Klesty & Karagiannopoulos, 2020). Nevertheless, Norway’s success in advancing electric car adoption can be attributed to two main factors. Firstly, Norway has a uniform national policy that covers all major incentive categories with the exception of fuel pricing benefits, namely parking access benefits, infrastructure usage pricing benefits (eg. ferries and toll roads), purchase price incentives, infrastructure access benefits (eg. bus lanes), and public charging infrastructure development (Mersky et al., 2016). Secondly, in addition to the comprehensiveness of Norway’s policies, the continuous support for EVs has allowed for increased visibility of EVs and allowed the market to mature (Eppstein et al., 2011).

Norway has been incentivizing the use of EVs since 1990 when purchase and import taxes were removed on zero-emissions vehicles (The Norwegian Electric Vehicle Association, n.d.). Norway puts a heavy emphasis on incentivizing the use of zero-emission vehicles such as BEVs, with special tax benefits, toll road exemptions, parking benefits, and other incentives (European Alternative Fuels Observatory, 2020). However, in recent years the country has given local municipalities more power over incentives with the requirement that ZEVs don't get charged more than 50% of the normal fee on ferries, toll roads, and public parking places (The Norwegian Electric Vehicle Association, n.d.). The country is aiming for all new vehicles by 2025 to be ZEVs (ibid).

Finland, on the other hand, has much more moderate policies towards EVs but does offer lower purchase and usage taxes based on CO2 emissions (Autoalan Tiedotuskeskus, n.d.). Additionally, in 2018 the Finnish Government introduced a new €6 million initiative to grant BEV buyers a €2000 subsidy requiring that the vehicle has a price of under €50 000 and is owned for a minimum of 3 years (TRAFICOM, n.d.). Norway's and Finland's current incentives towards EVs have been summarized in Tables 1 and 2.

Table 1: EV incentives in Finland

Years in force	Policy	Additional information
2011-	Fuel tax (disincentive for ICEVs)	- Based on energy content and CO2 emissions
Last updated 2013	Lower vehicle tax	- Based on vehicle use - Rate based on CO2 emissions and vehicle weight - Basic component and tax on motive power
Last updated 2018	Lower car tax	- Based on CO2 emissions - BEVs pay the lowest rate of 2,7%
2018-2021	€ 2000 BEV purchase	- Maximum price of

	grant	vehicle € 50 000 - Applies to private individuals - Minimum 3 years ownership
	Local/ other incentives	- Helsinki offers -50% parking fee for low emissions vehicles - Some private companies offer reduced rate or free charging for customers (eg. K-Group and S-Group)

Sources: Autoalan Tiedotuskeskus (n.d.), City of Helsinki (2019), Loikkanen (2018), TRAFICOM (n.d.)

Table 2: EV incentives in Norway

Years in force	Policy	Additional information
1990-	No import/purchase tax for BEVs	- Based on CO2 emissions - PHEVs pay a lower rate
1996-2020	Lower annual road tax	- Based on fuel type - Exemption removed in 2020
1997-2017	No toll road or ferry fees	- Maximum 50% fee currently
1999-2017	Free municipal parking	- Maximum 50% fee currently
1999-	EV registration plates	- Allows for easy implementation of incentives - Eg. bus lanes and toll roads
2000-2018	50% reduction in company car tax for BEVs	- Reduced to 40% in 2018
2001-	25% VAT exemption for	- Extended to leasing in

	BEVs	2015
2005-	Access to bus lanes	- Local authorities can limit access
2016-	Minimum 6% of parking places reserved for EVs	
2017-	Public funding for fast charging every 50km	

Sources: European Alternative Fuels Observatory (2020), The Norwegian Electric Vehicle Association (2020), Steinbacher et al. (2018)

Multiple studies have also concluded that stable and coherent policies are required to advance EV adoption (Kivimaa & Virkamäki, 2013; Kester et al., 2018). Stable policies provide consumers with a level of certainty regarding the benefits of EV ownership and thus promote the adoption of EVs while allowing policymakers time to observe the effects of each policy carefully (Langbroek et al. 2016). This is illustrated by Denmark, where multiple policy changes in recent years along with regressive tax policies have hampered the EV market, whereas Norway has had consistent policies in place, which will slowly be phased out as the market matures while still providing EVs with a distinct price advantage (Kester et al., 2018).

Furthermore, as Lah (2015) points out, a comprehensive policy approach is required which covers fuel efficiency standards, differentiated vehicle taxation, and city design, because each policy has certain advantages and disadvantages. For example, fuel efficiency standards are relatively easy to implement because they affect OEMs rather than individual consumers while indirectly reducing the cost of driving (ibid). Policies can also have negative effects, such as a sizeable loss in toll revenue in Norway after EVs were exempt from toll fees (Aasness & Odeck, 2015). Norway’s heavy incentives have also been criticized as favoring the wealthy since many of the incentives, like toll road exemptions and free parking, are aimed at making the TCO lower while EVs are still more expensive relative to used ICEVs which dominate the second-hand market (Nikel, 2019).

Another important aspect of policies and financial incentives is regional differences. Even though Norway has managed to promote EV adoption successfully that doesn’t mean the same policies can simply be implemented elsewhere with the same results highlighting the importance of local policy flexibility. For instance, in a series of expert interviews within the Nordic countries, Kester et al. (2018) discovered that the importance of charging infrastructure was emphasized in Finland because it was seen as an opportunity for local companies as well as a public benefit, whereas toll road exemptions wouldn't be viable because Finland doesn't have toll roads. Sierzchula et al. (2014) point out that even though financial incentives and charging infrastructure are the two best predictors of EV adoption rates generally, country-specific factors help to explain the differences in adoption rates and therefore policies need to be tailored to each country. Within Finland increasing the size of the purchase incentive, exemption for BEVs from registration and ownership tax, and expanding incentive policies to cover company cars in addition to private cars have been suggested as effective policy measures (Sundström, 2018).

However, there are some clear policy recommendations supported by the research that seem to be universal. Firstly, education is often noted as a policy priority within the literature because consumers need to be made aware of the benefits of EVs in order to create interest in them (Larson et al., 2014; Kester et al., 2018). Humans are naturally resistant to change and need to be convinced of the benefits of new technological advancements before adopting them (Dent & Goldberg, 1999). Higueras-Castillo et al. (2019) argue that governments and OEMs should focus on emotional issues, such as vehicle acceleration, low engine noise, and lower ownership costs because this strategy has been shown to have a positive impact on consumer attitudes. Furthermore, promoting pro-environmental attributes and innovativeness of EVs may help as these attributes have been identified as drivers of adoption (Rezvani et al., 2015). Another finding supported by the literature is that incentives should be focused on purchase prices and taxation measures should be used rather than subsidies (Kester et al., 2018; Holland et al., 2016). This is hardly surprising due to the fact that consumers put a greater emphasis on upfront costs as compared to ownership costs and putting a direct price on externalities has been shown to be more effective than indirect corrective policies (ibid).

2.8. Conceptual Framework

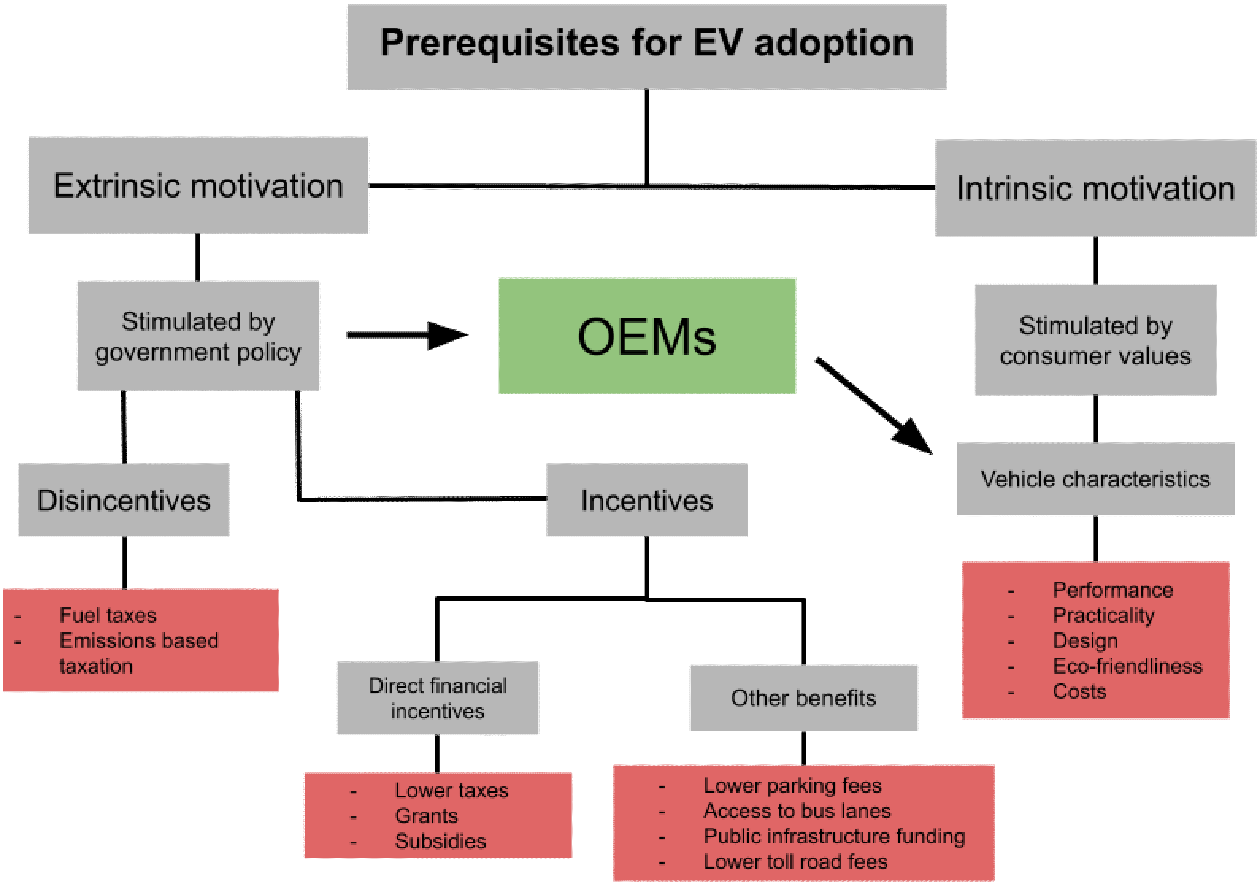

Figure 1 - Conceptual Framework

The conceptual framework (see Figure 1) has been developed based on the literature on consumer opinions regarding EVs and barriers to EV adoption. The adoption of EVs and other AFVs will be important in the de-carbonization of the transport sector and therefore it is important for governments to understand consumer behavior and implement sensible policies to promote EV adoption. Furthermore, OEMs gain to benefit by recognizing customer concerns and opinions regarding EVs. In order for EVs to become widely accepted by consumers, they must satisfy the needs of consumers and be considered viable alternatives to ICEVs. However, EVs face numerous barriers to adoption currently, as has been outlined in this literature review. A major barrier is also the fact that consumers tend to avoid new technological innovations that are seen as unproven, which means that willingness to accept is low, indicating that consumers discount the benefits of EVs in favor of conventional technology (Hoen & Koetse, 2014). The theoretical models proposed by Davis (1989) and Rogers (1962) reinforce this finding.

The conceptual framework is based on the concept that in order for a consumer to adopt an EV in favor of an ICEV their personal levels of intrinsic and extrinsic motivation need to be sufficient and greater than that for an ICEV. Intrinsic motivation is stimulated by the characteristics a consumer values in and EV, such as performance attributes, design, perceived eco-friendliness or potential cost savings. Some of these attributes can be considered functional, such as performance or charging speed, whereas others appeal to social identities, such as the eco-friendliness of a vehicle, and others appeal to emotions, such as the joy or pleasure that a consumer experiences while driving a vehicle (Branderhorst, 2018). On the other hand, extrinsic motivation is increased by offering a reward for adoption and is therefore stimulated by government policy in the form of incentives and disincentives. The levels of intrinsic and extrinsic motivation will differ with each consumer, which highlights how consumers value different attributes in EVs and respond to policies differently (Langbroek et al., 2016).

Some key examples of incentives and disincentives have been included in the conceptual framework. Fuel taxes are an effective way of discouraging the use of ‘dirty’ fuels which in effect increases the competitiveness of cleaner alternatives. Similarly, emissions-based taxation favors vehicles that produce less GHG emissions. Incentives can be broadly categorized as direct financial incentives because they intend to decrease the purchase price of a vehicle, and other benefits, which attempt to make the ownership of an EV more convenient or lower ownership costs. Tax policies and subsidies towards purchasing an EV are examples of direct financial incentives whereas lower parking fees, public infrastructure development, and access to bus lanes would be examples of other incentive measures. Combining incentives and disincentives is important because not only does it lead to a greater stimulus for adoption, but it also helps governments gain lost revenue from incentive policies.

A third stakeholder, OEMs, is also included in the framework along with the government and consumers. The government can influence OEMs through regulations, such as increasing fuel efficiency standards. On the other hand, OEMs have control over vehicle characteristics. OEMs can increase adoption rates by being more receptive to consumer requirements and consequently designing better vehicles. Furthermore, OEMs can stimulate adoption through marketing such as highlighting the eco-friendliness of a product, the innovativeness of a product, or potential TCO savings, because these attributes have been identified as drivers of adoption which suggests that highlighting these features would be an effective marketing strategy (Rezvani et al., 2015; Higueras-Castillo et al., 2019).

The goal of this study is to identify the main barriers to EV adoption within Finland as well as offer policy recommendations based on consumer opinions regarding EVs. This relates to the conceptual framework in the sense that the intrinsic and extrinsic motivating factors for adoption will be analyzed. Although the literature on EVs and specifically consumer opinions regarding EVs has grown substantially in recent years across geographic locations the amount of research carried out in Finland is sparse. This research will hopefully provide new insights into consumer opinions within Finland as well as provide meaningful policy recommendations. Several hypotheses have also been developed based on the literature review.

3. METHODOLOGY

3.1. Hypotheses

Three hypotheses have been identified based on the objectives and previous literature:

H1: Experience with EVs positively impacts perceptions of EVs.

H2: Experience with EVs positively impacts knowledge of EVs.

H3: People with favorable views of EVs also believe the government should play a more active role in increasing EV adoption rates.

3.2. Rationale Behind Methodology

Firstly, a quantitative approach was chosen over a qualitative approach. A quantitative approach was chosen because it enabled the collection of numerical data that could be converted into statistics. This data could then be compared with findings from previous studies. Secondly, an online survey was chosen as it was the easiest and most convenient way of collecting a sufficient amount of data. It would have been difficult to achieve a large enough sample size utilizing other methods such as interviews or focus groups.

3.3. Data Collection Process

The survey was created using Webropol software, which was provided by Aalto University. The survey was distributed using different electronic channels and shared in different social groups. The main distribution channel was email and the survey was distributed to students at the Aalto University Mikkeli Campus. Other channels included Facebook, WhatsApp, and Snapchat. The survey was open for 14 days and 71 people answered the survey. In total four open-ended answers were discarded as they didn't make sense or were made jokingly. The full survey has been included in Appendix 1.

3.4. Survey Design

The survey was completely anonymous and respondents were allowed to skip questions or exit the survey at any time. This was done to increase the likelihood of participation and also allowed respondents to neglect questions they felt they couldn't answer or didn't feel comfortable answering. This may have been the case for some respondents due to the technical terminology used in various questions. However, respondents were also given the option of returning to the survey if they wanted to complete the survey at a later time.

In total, the survey included 27 questions with seven demographic questions included at the end of the survey. Respondents were asked what their nationality, age, gender, student and employment status, education level, and income level was. The last question asked respondents whether they lived in rural, urban, or suburban area. Multiple different question designs were utilized in the survey, namely dichotomous questions, multiple-choice questions, Likert scale questions, as well as one open-ended question. The questions were designed to cover the following topics:

1. Experience and knowledge of EVs
2. Transportation habits
3. Opinions and perceptions regarding EVs
4. Willingness to pay for EVs
5. Opinions on EV policy incentives

The first question in the survey explained the purpose of the survey, laid out the terms of the survey, and asked respondents whether they agreed to these terms. After agreeing to the terms of the survey, a question on the country of residence of respondents was included at the very beginning to eliminate respondents who did not reside in Finland due to the nature of the research. Although respondents outside of Finland may have added some value to the study, the focus of the survey was to study consumer opinions regarding EVs and EV incentive policies within Finland. Therefore, in order to attract respondents residing in Finland, the survey was not distributed within other countries and only residents of Finland were asked to answer the survey. No other excluding criteria was used, such as ownership of a driver's license or sufficient knowledge of EVs. Finnish citizenship was also not a prerequisite for answering the survey.

Questions 3-6 were multiple-choice questions that inquired respondents on their experience with EVs and other types of vehicles. Specifically, respondents were asked what type of vehicles they owned, had driven, or had traveled in. Additionally, respondents were asked what type of vehicle they would consider buying in the future and when they were looking to buy a vehicle. Questions 8 and 9 pertained to respondents' transportation habits. Respondents were asked what their main form of transportation was and how often they drove a car. Question 10 was a Likert scale question that had 11 statements regarding EVs and respondents had to indicate whether they agreed or disagreed with the statements. The question was meant to test respondents' knowledge and perceptions of EVs. For example, respondents had to indicate whether they perceived EVs to be environmentally friendly and whether they knew a lot about them. Question 11 was meant to test respondents' knowledge of the EV incentives in Finland. Respondents were asked to indicate whether they knew the size of the government grant towards the purchase of an EV between 2018-2021 in Finland. While in question 10 respondents could freely indicate whether they were familiar with the EV incentives in Finland, question 11 was a way of quantifying this knowledge.

Question 12 was another Likert scale question. Respondents were provided with a short text on the state of the Finnish EV market and told some of the benefits of EVs. Five statements regarding the role of the government in increasing adoption rates were provided and respondents had to indicate their level of agreement. For example, respondents had to indicate whether they believed the government should incentive the use of EVs more heavily or disincentive the use of ICEVs.

Question 13 was a Likert scale question that asked respondents to rate the appeal of different EV incentives. Seven different incentive policies were provided, including lower purchase tax or grant for an EV, lower in-use taxes, other parking benefits, subsidized electricity costs, public charging infrastructure funding, and access to bus lanes. Incentives policies such as reduced toll road fees were not included as Finland does not have toll roads. Question 14 inquired respondents on their willingness to pay for EVs in relation to ICEVS. Respondents had to choose between seven different options ranging from more than 20% less to more than 50% more.

Question 15 was a dichotomous question where respondents had to indicate whether they were familiar with the term vehicle-to-grid (V2G). This was important to establish as question 16 included this term. Furthermore, previous research indicates that consumers are not familiar with the term V2G. Most notably, Noel et al. (2019) found that in the Nordic countries 90% of respondents in their study didn't know what the feature was and therefore it wasn't held in high regard. The results of this survey could, therefore, be compared with the findings from this earlier study.

Questions 16 and 17 were Likert scale questions were respondents had to rate different benefits and drawbacks of EVs. These questions were key questions in the survey as they provided insights into the barriers to the adoption of EVs. Question 16 included eight different benefits associated with EVs, including reduced GHG emissions, lower maintenance costs, and lower fueling (electricity) costs. Question 17 included seven drawbacks associated with EVs including range constraints, higher purchase prices, and infrastructure constraints.

Question 18 inquired respondents on the timeframe in which they would need to save money considering the total cost of ownership of an EV when ownership and purchase costs were accounted for. Respondents were given 5 different time frames to choose from ranging from 0-1 year to over 10 years. Additionally, respondents could choose to respond by saying they didn't need to save money on TCO or that they wouldn't consider buying an EV even if they saved money on TCO.

Question 19 inquired respondents on their range requirements. A short text was included informing respondents that in 2017 Mellinger et al. (2018) found that EVs could cover 85-90% of journeys within Finland. Respondents then had to indicate how far a vehicle would have to travel on a single charge to cover 90% of their own travel requirements. Question 20 was the last question in the survey before the demographic questions. It was an open-ended question where respondents were asked to explain in their own words what would make them consider buying a BEV in the future. This question was included because it allowed respondents to freely express how they felt about the topic without being confined to predetermined choices.

3.5. Sample Selection and Criteria

Before launching the survey three people were chosen for a trial run to determine how long it would take to complete and whether the questions were easy to understand. A convenience sampling method and snowball sampling method were used in the survey. A convenience sampling method was chosen to increase the sample size. While the snowball method also contributed to a larger sample size it also ensured a more diverse sample. Furthermore, a more diverse and representative sample was achieved by distributing the survey via multiple different channels in different social groups. The only criteria for answering the survey was that respondents had to reside in Finland. In total, 75 people attempted to answer the survey, but four people were rejected because they didn't reside in Finland. IBM SPSS statistical analysis software was used to analyse the data from the survey.

4. FINDINGS

4.1. Demographics

The survey included seven different demographic questions. All the data has been compiled and converted into charts (see Figures 2-8). The vast majority of respondents were from Finland accounting for 86% (N=61) of all respondents.

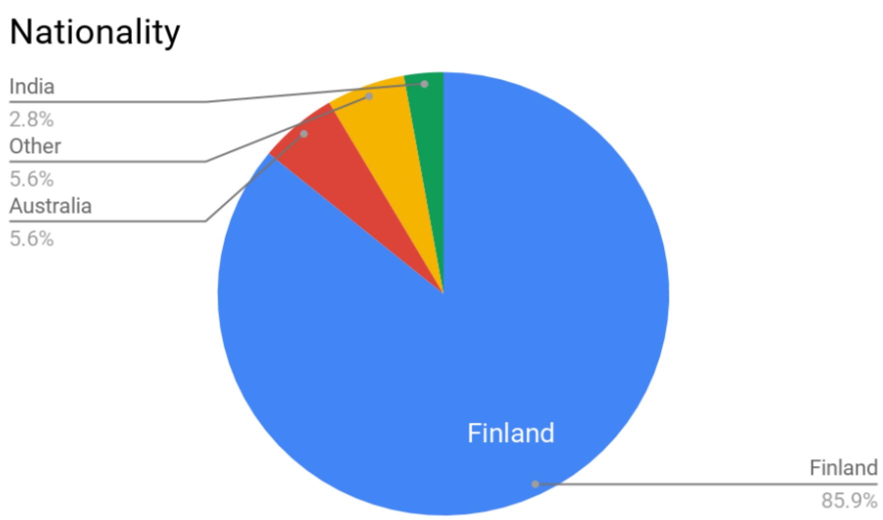

Figure 2 - The nationalities of respondents

Most respondents were young adults with people between the ages of 18-21 and 22-25 accounting for more than 60% of respondents.

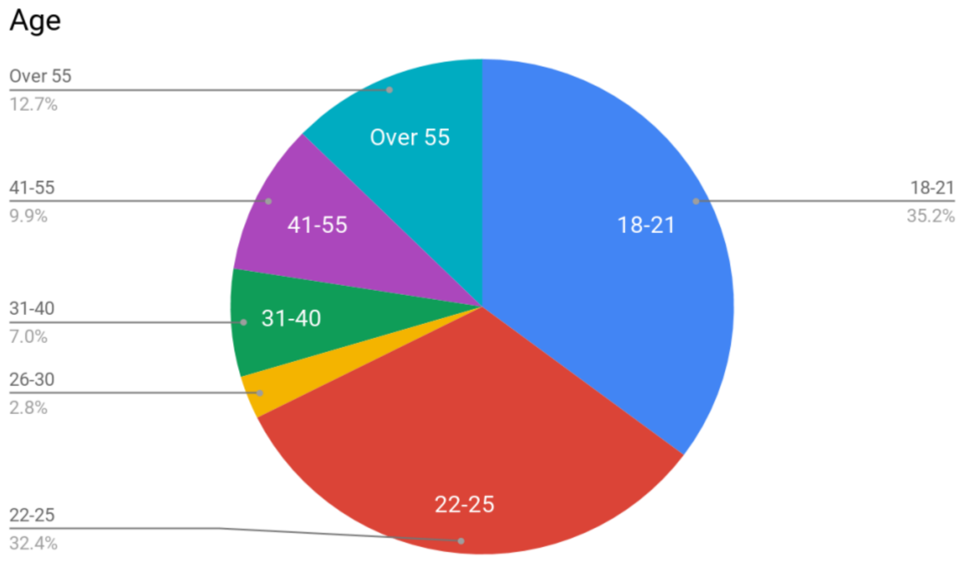

Figure 3 - The age of respondents

The sample was also very male dominant at 63% (N=44) male and 34% (N=24) female.

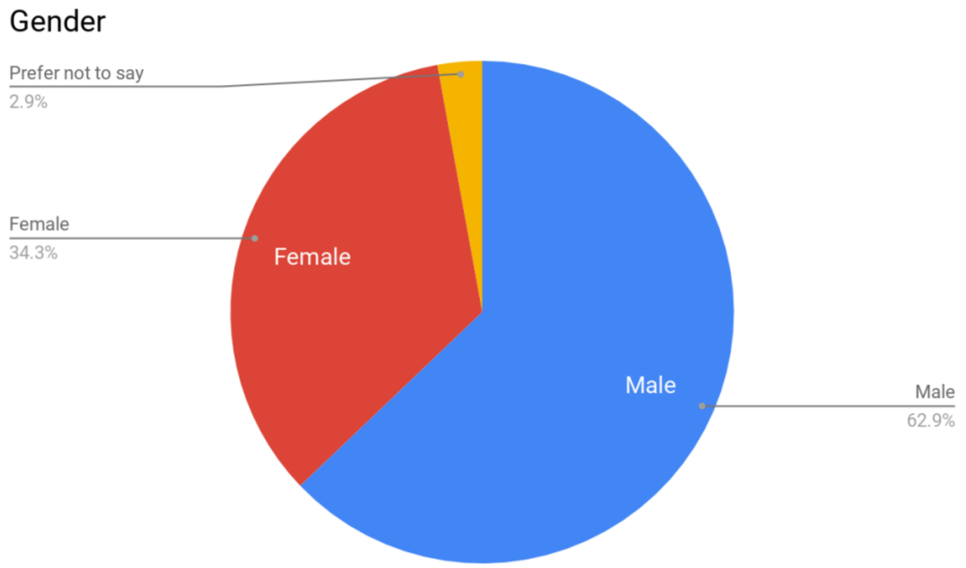

Figure 4 - The gender of respondents

Furthermore, a large portion of respondents were students. These results were expected as the survey was mainly distributed to university students.

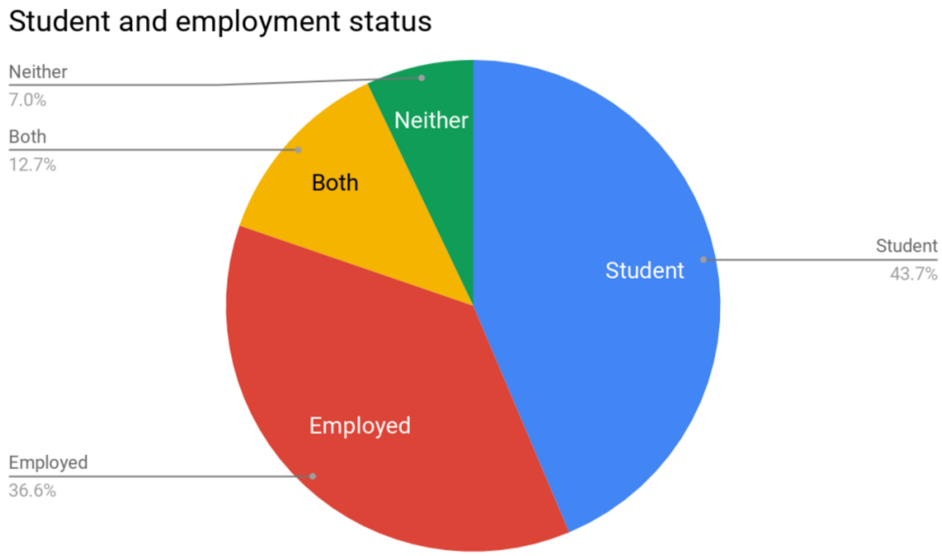

Figure 5 - The student and employment status of respondents

This was also apparent from the education level of respondents as 36% of respondents said they didn’t have a degree but were currently in university.

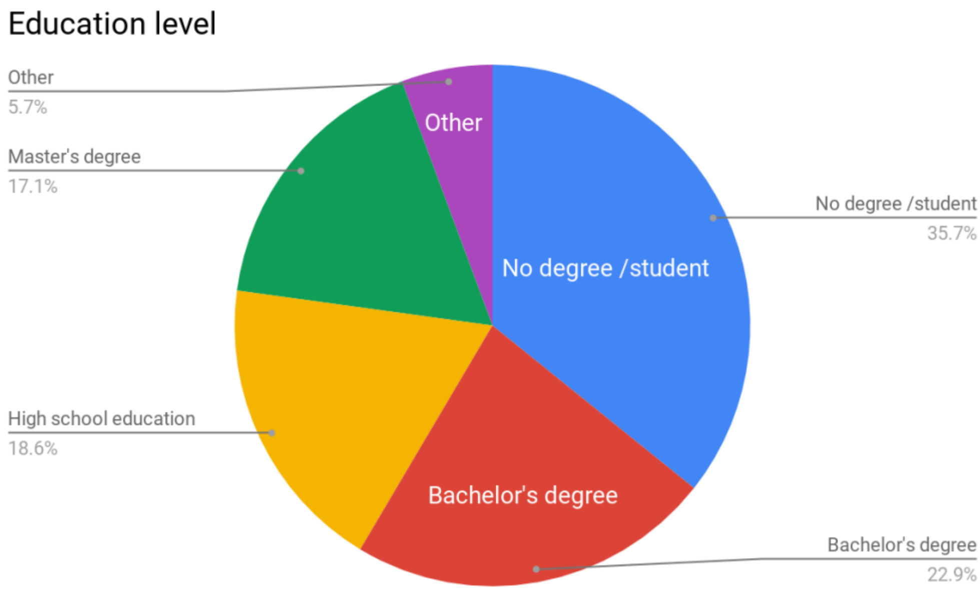

Figure 6 - The education level of respondents

The high percentage of students was also apparent is the income level of respondents. 40% of respondents made between 0- 10 000 euros a year.

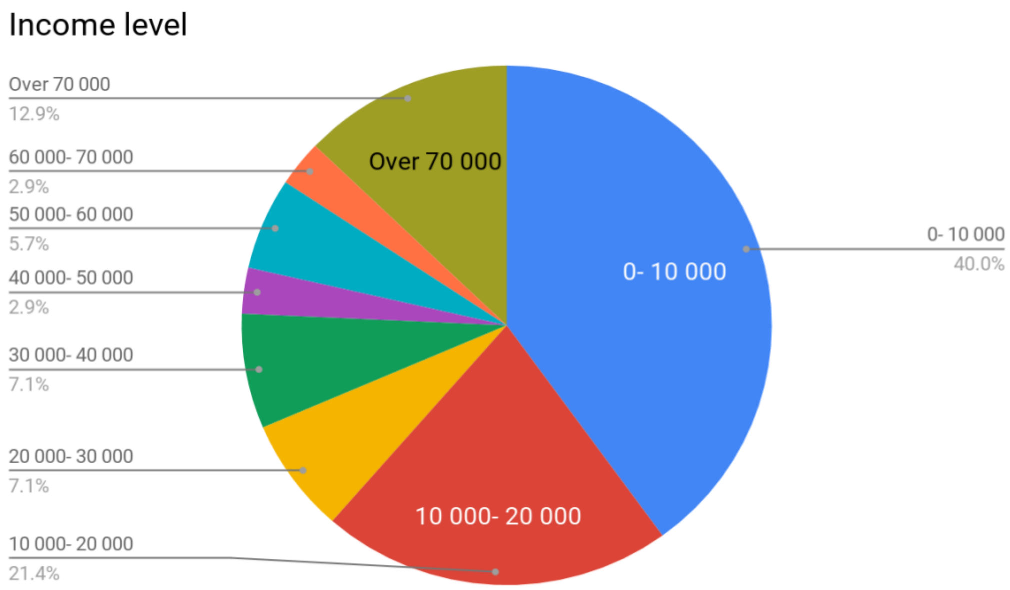

Figure 7 - The income level of respondents

Unsurprisingly, the vast majority of respondents also lived in urban areas.

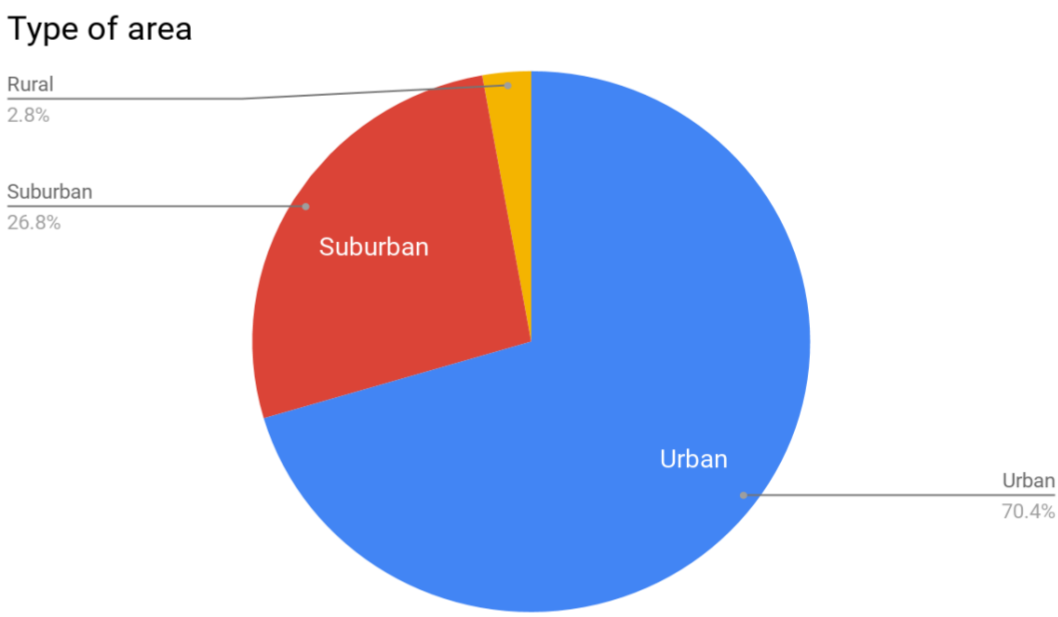

Figure 8 - The type of area where respondents resided

4.2. Experience with EVs

Out of 71 respondents, 44% (N=31) said that they owned an ICEV and 55% (N=39) said that they didn't own a car. Only one person said they owned a hybrid vehicle and one person said they owned another type of vehicle. Zero respondents said that they owned a BEV. Interestingly the majority of respondents at 74% (N=52) said that they had traveled in a hybrid vehicle and 40% (N=28) said they had traveled in a BEV. However, when asked whether respondents had driven one of these vehicles only 32% (N=22) said they had driven a hybrid vehicle and 16% (N=11) had driven a BEV.

Even though the majority of respondents had limited experience with EVs when asked whether they would consider buying an EV in the future the results were promising. 75% (N=52) of respondents said they would consider buying a hybrid vehicle and 74% (N=51) said they would consider a BEV. On the other hand, only 55% (N=38) of respondents said they would consider buying an ICEV. Furthermore, a plurality of respondents at 42% (N=30) said they were looking to buy a car within 4-7 years. This indicates that despite the current limitations of EVs consumers believe these limitations will be overcome in the relatively near future.

4.3. Perceptions and Knowledge of EVs

Question 10 was used to measure respondents' perceptions and knowledge of EVs on a seven-point Likert scale ranging from strongly agree to strongly disagree. Six of the statements tested respondents on their perceptions of EVs. The first statement simply stated, 'I have a favorable view of EVs.' The vast majority of respondents indicated some level of agreement with this statement. 23% strongly agreed with this statement, 41% simply agreed, and 21% somewhat agreed. Furthermore, respondents were asked whether they perceived EVs to be environmentally friendly, practical, and physically appealing, in comparison to ICEVs. Respondents were also asked to indicate if they felt BEVs could perform as well as ICEVs and meet the majority of their travel needs.

The responses to the different statements have been summarized in Figure 9. Overall, respondents had a favorable view of EVs across multiple different attributes. BEVs were rated most favorably when it came to their physical appeal. 90% of respondents indicated some level of agreement when asked if BEVs could be just as physically appealing as ICEVs. Most respondents also perceived EVs to be environmentally friendly with 87% of respondents indicating some level of agreement with this statement. The only area where BEVs were rated relatively poorly was practicality. 54% of respondents indicated some level of agreement when asked if they believed BEVs to be less practical than ICEVs. However, most respondents also believed that a BEV could meet the majority of their travel needs. Interestingly, when asked how far a BEV would have to travel on a single charge to meet 90% of their requirements, the responses were mixed (see Figure 10).

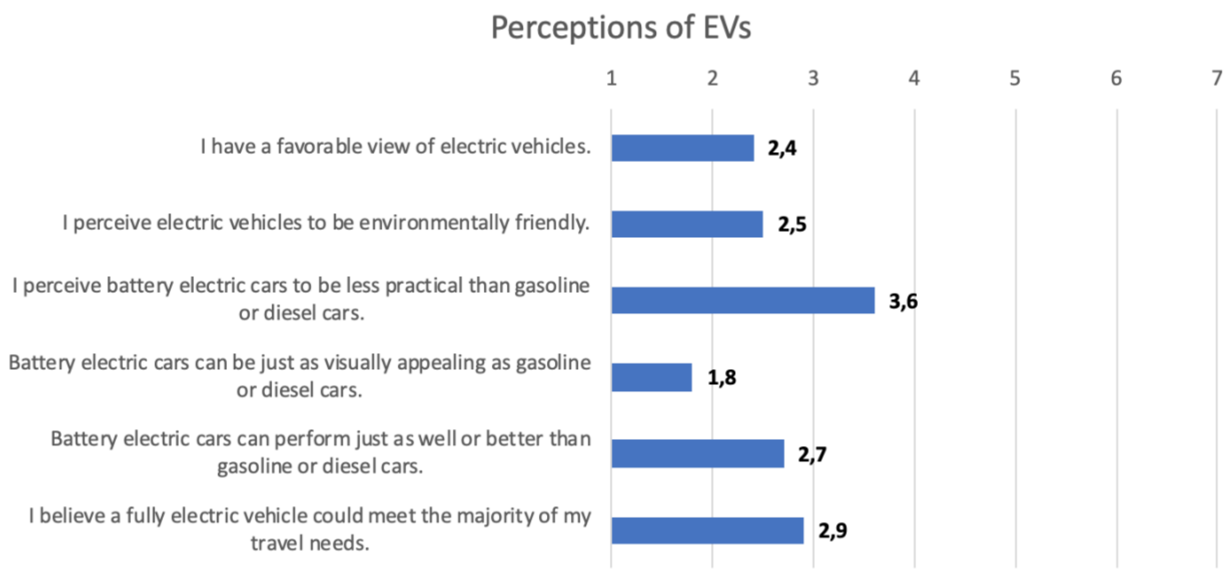

Figure 9 - Mean of responses to perception statements (1= strongly agree, 4=neutral, 7= strongly disagree)

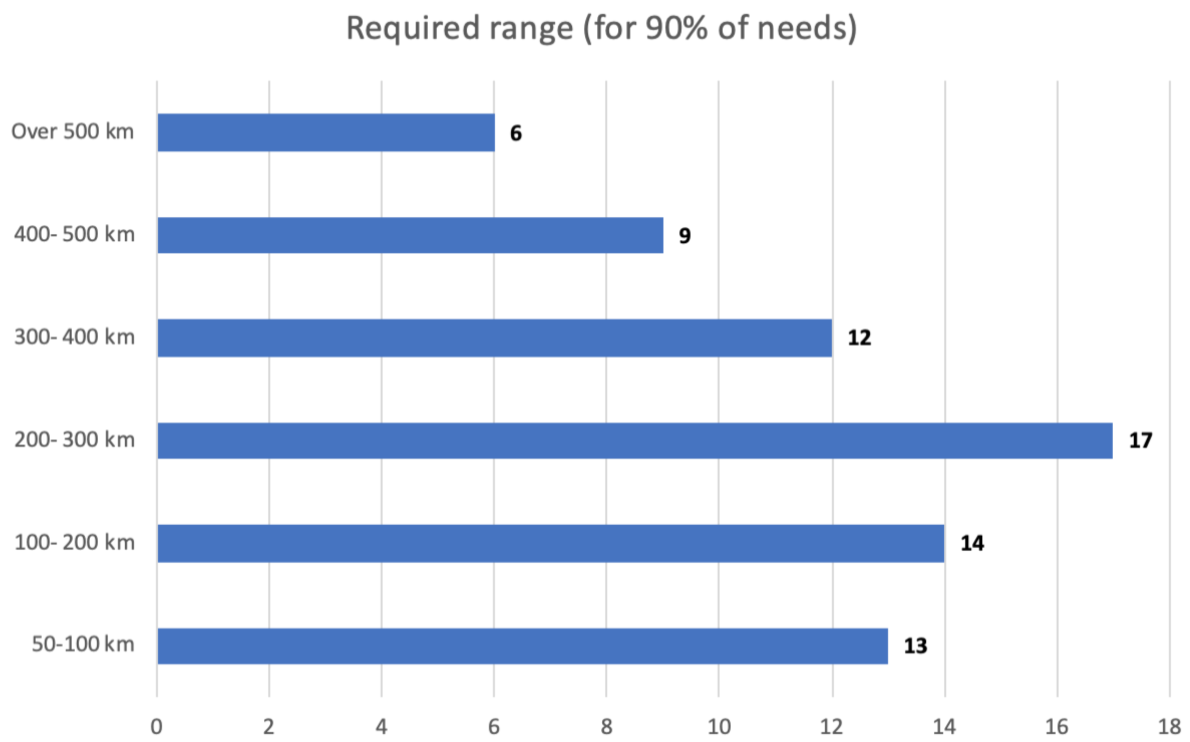

Figure 10 - Range to satisfy 90% of respondents' requirements

Question 10 also included four statements pertaining specifically to the knowledge of EVs. The average responses to these statements have been summarized in Figure 11. Respondents were most familiar with the benefits of EVs with 80% of respondents indicating some level of agreement when asked if they were familiar with the benefits of EVs. Respondents were less familiar with the drawbacks of EVs and most respondents indicated that they weren't familiar with the EV incentive policies in Finland. This was reinforced by the finding that only 22% (N=14) of respondents to the survey knew how large the government grant towards a BEV was. These findings highlight the need for consumer education as previous research has also found.

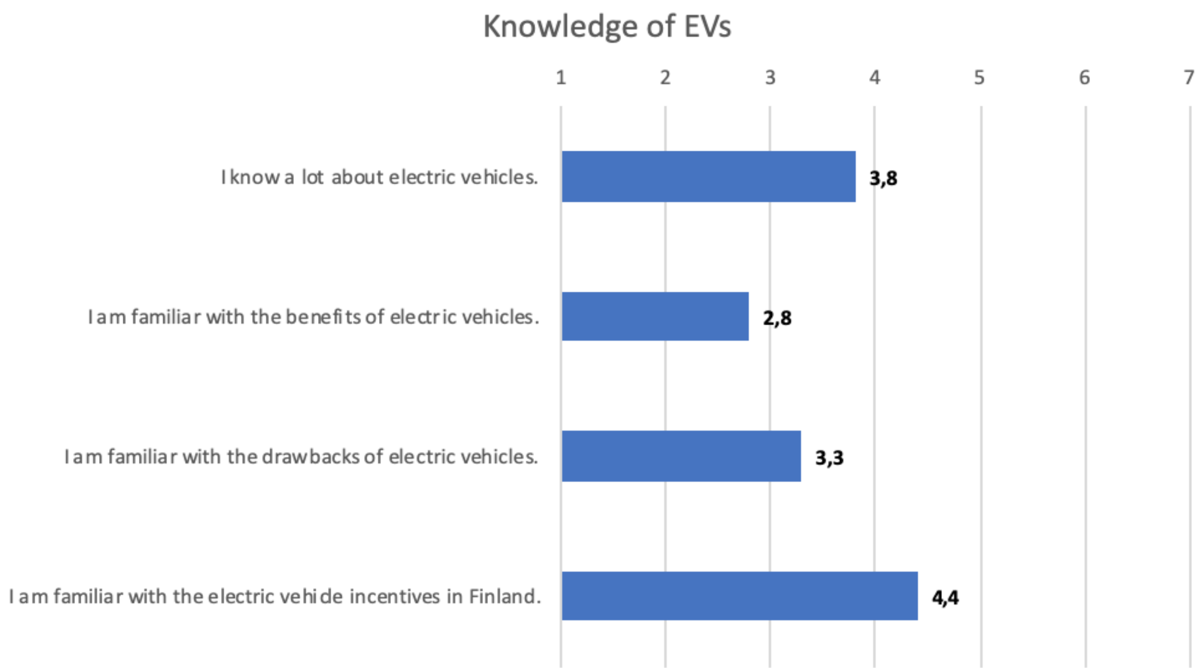

Figure 11 - Mean of responses to knowledge statements (1= strongly agree, 4=neutral, 7= strongly disagree)

4.4. Total Cost of Ownership and Willingness to Pay for EVs

The majority of respondents indicated that they would be willing to pay either the same or slightly more for an EV. 53% (N=36) of respondents said they would pay between 10-20% more for an EV compared to a gasoline or diesel car. 29% (N=20) said they would pay the same. Furthermore, when asked to consider the TCO of a vehicle 37% (N=26) of respondents said they would need to save money compared to an ICEV within 3-5 years and 29% (N=21) said between 5-10 years. Respondents were also asked if they considered purchase prices to be more important than ownership costs on a seven-point Likert scale. The mean score was 4,2 indicating that most people didn't agree with this statement. This was somewhat surprising, as previous research has indicated the opposite (Hagman et al., 2016). However, consumers may act differently in the real world as purchase prices have been shown to be a major limitation of EVs even though they are generally viewed positively (Bühne et al, 2015). However, research also supports the view that providing TCO information does make a difference on consumer opinions (Dumortier et al., 2015).

4.5. Opinions on the Benefits and Drawbacks of EVs

A key focus of the study was to determine what respondents perceived to be the major benefits and drawbacks of EVs. While question 10 was used to determine if respondents were familiar with the benefits and drawbacks of EVs, questions 16 and 17 were used to measure opinions relating to these attributes. Reduced air pollution was rated most highly when it came to the benefits, closely followed by eco-friendliness (see Figure 12). This would indicate that emphasizing the benefits of EVs on the environment is an effective way of increasing adoption rates, which is supported by previous research (Rezvani et al., 2015).

Interestingly, the ability to charge the vehicle at home was rated very highly and above savings from electricity or maintenance costs. This indicates that emphasizing the practicality of EVs may be an effective strategy for increasing adoption rates. Vehicle-to-grid capability was rated as the least appealing feature. This wasn't surprising as 84% of respondents didn't know what the feature was. This is consistent with Noel et al (2019) who found that 90% of people in their survey, which was done in the Nordic countries, didn't know about the feature. Again, this highlights the need for educating consumers on the benefits of EVs, as both OEMs and the government stand to benefit.

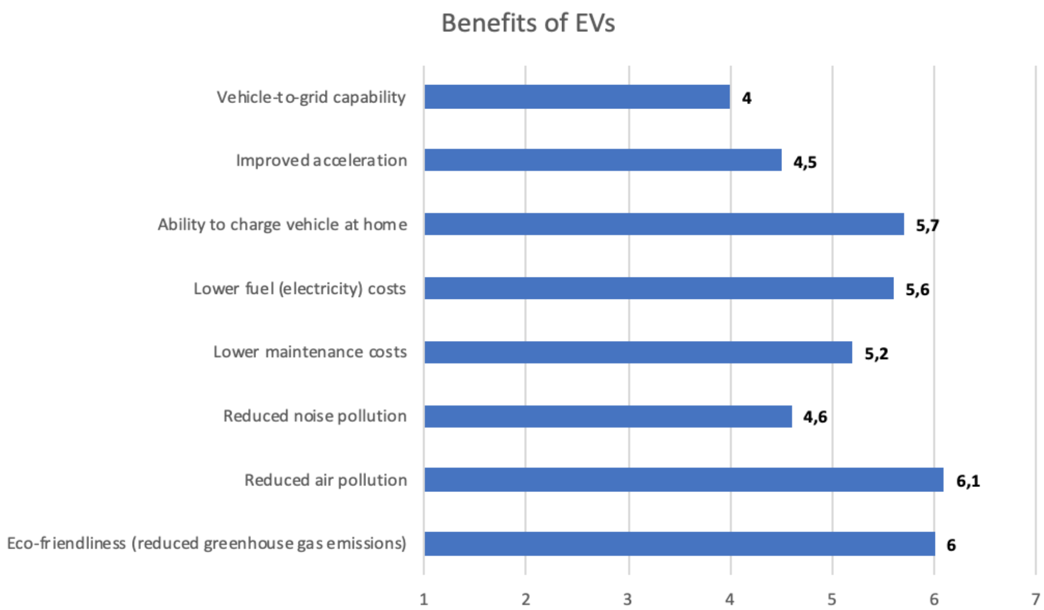

Figure 12 - Consumer opinions on benefits associated with EVs (higher number indicates a higher rating)

Charging infrastructure constraints were rated as the most severe limitation of EVs (see Figure 13). This isn't surprising as the public charging infrastructure in Finland is still relatively underdeveloped compared to other countries like Norway, especially in rural and more northern parts of the country. For a point of reference, in 2019 Norway had close to 14,000 public charging stations compared to just over 1250 in Finland (European Alternative Fuels Observatory, 2019). This translates to 655 stations per 100km of highway in Norway compared to just 50 per 100km in Finland (ibid). However, the charging infrastructure in Finland is improving rapidly with many private companies developing their own charging networks. For example, the K-Group has been developing its own charging network by installing stations at supermarkets and has the largest fast-charging network in Finland currently (K-Group, 2020). Previous research has also indicated that improving charging infrastructure is emphasized in Finland in relation to other Nordic countries (Kester et al., 2018).

Unsurprisingly, slow charging speed and high purchase prices were also rated as severe limitations. However, range constraints were only rated as the fourth most severe limitation contrary to previous research (Egbue & Long, 2012; Gyimesi & Visvanathan, 2011). Considering the other findings from the survey, this would indicate that as long as consumers have access to a comprehensive charging network, have the option of charging at home, and charging speeds are improved, range becomes less of an issue. Furthermore, as battery technology improves range will become even less of an issue. Lower resale was rated as the least severe drawback of EVs. The responses to question 20, an open-ended question where respondents could cite more than one prerequisite for considering a BEV in the future, have been compiled in Figure 14. Lower purchase prices and improved range were most frequently cited as prerequisites for BEV adoption. Improved charging infrastructure was the third most frequently cited requirement.

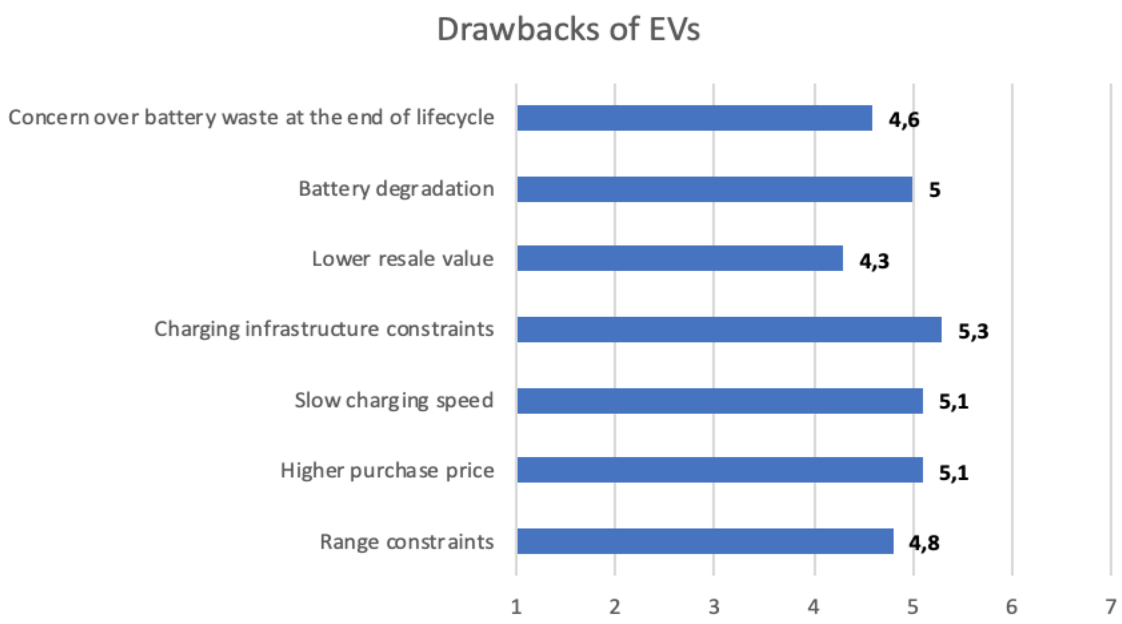

Figure 13 - Consumer opinions on drawbacks associated with EVs (higher number indicates higher severity)

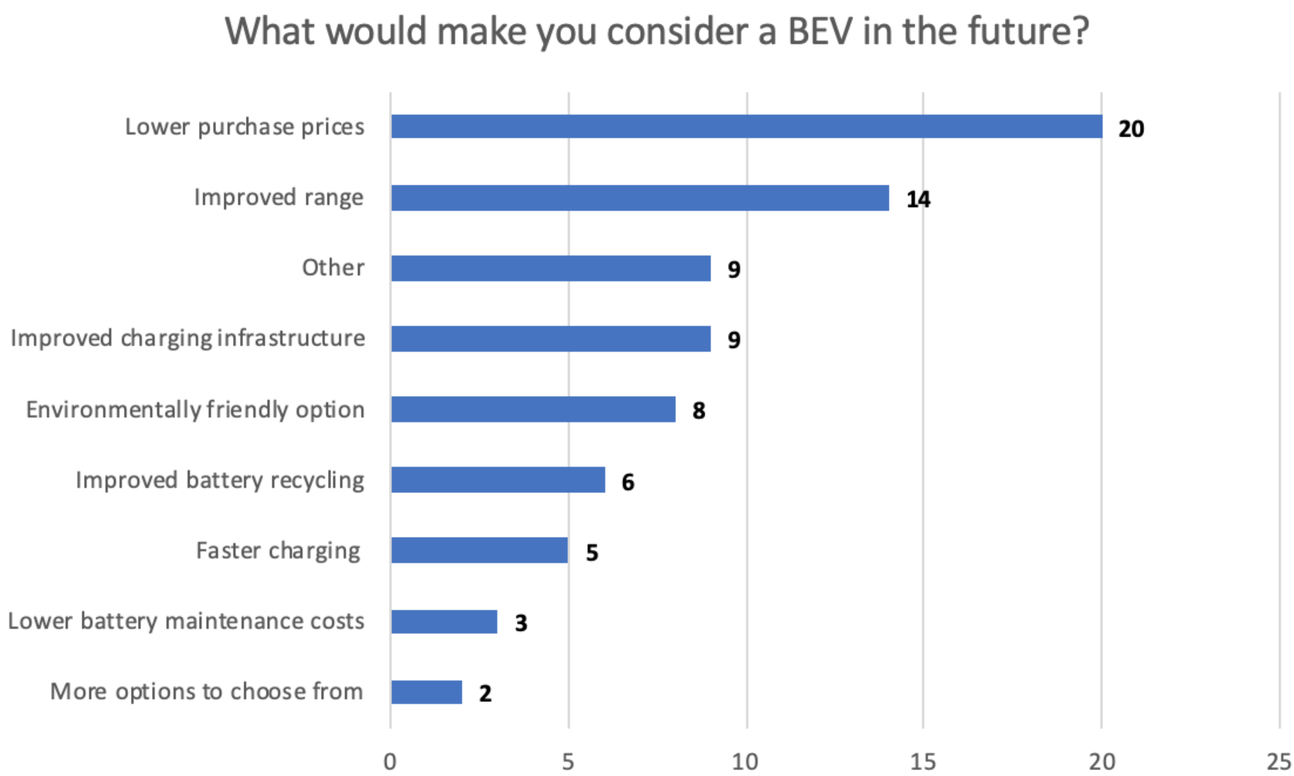

Figure 14 - What would make respondents consider buying a BEV in the future

4.6. Opinions on Government Policy Incentives

Overall, most respondents to the survey felt that the government should incentivize the use of EVs more heavily. 81% of respondents indicated some level of agreement with this sentiment. Public charging infrastructure funding was rated as the most attractive incentive policy (see Figure 15). This is consistent with the other findings from the survey. Lower in-use taxes and a lower purchase tax were also considered equally good incentive policies. Subsidized electricity costs were also seen as a good incentive policy. These findings indicate that incentive policies aimed at making the ownership of an EV cheaper or more convenient may be just as effective as focusing on making purchase prices lower, which is somewhat contrary to previous findings. This has been the aim of the Finnish government's 2000€ grant towards EV purchases. Therefore, a more comprehensive policy approach is required with an emphasis on improving charging infrastructure.

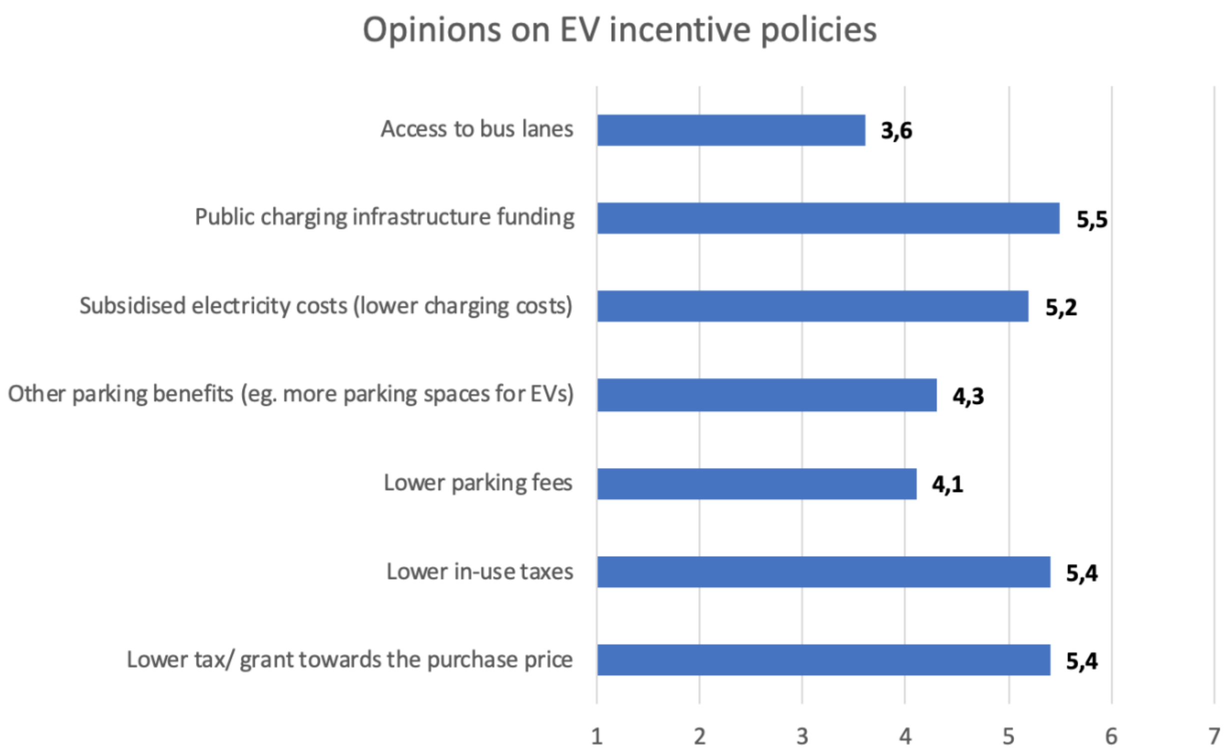

Figure 15 - Consumer opinions on EV incentive policies (higher number indicates a higher popularity rating)

5. ANALYSIS

5.1. H1: Experience with EVs positively impacts perceptions of EVs

To determine whether experience with EVs had a positive impact on peoples' perception an independent T-Test analysis was used. People with experience were defined as having either traveled in a hybrid vehicle or BEV. Perceptions were measured by combining the six perception statements and turning them into a scale with a lower number indicating a stronger level of agreement. Statement 9 was re-coded first to make sure all the statements were worded positively and consistent with each other. Combined, the statements had a Cronbach's alpha score of α= 0,761 meaning that they were internally consistent (see Table 3). However, only the statement pertaining to the eco-friendliness of EVs had a statistical significance of less the 0,05 highlighted in yellow in Table 3.

Furthermore, the data didn't support the hypothesis that people with experience have a more positive perception of EVs as people with experience had a mean score of 2,75 compared to 2,7 for those without experience, $t\ (67) = -0{,}169$, $p = 0{,}867$ (see Appendix 2). It is important to note that this result may have been due to the small sample size (N=71). A larger sample size would have been required to make more definitive conclusions. However, considering the differences between hybrid vehicles and conventional ICEVs are much less pronounced than with BEVs this may explain why including experience with hybrids didn't result in significant differences in perceptions.

On the other hand, when only people with experience in a BEV were compared to those with no experience the differences were more pronounced. When these two groups were compared, people with BEV experience had a mean score of 2,5 compared to 2,9 for those with no experience, $t\ (67) = 1{,}674$, $p = 0{,}099$ (see Appendix 2). This would indicate that people with experience with BEVs generally do have more positive perceptions of EVs but the data here is inconclusive.

Question / statement	Statement	Significance (2-tailed)
Q10 S1	I have a favorable view of electric vehicles	0,769
Q10 S2	I perceive electric vehicles to be environmentally friendly.	0,02
Q10 S6	I believe a fully electric vehicle could meet the majority of my travel needs	0,875
Q10 S9R	I perceive battery electric cars to be less practical than gasoline or diesel cars. (re-coded)	0,455
Q10 S10	Battery electric cars can be just as visually appealing as gasoline or diesel cars.	0,115
Q10 S11	Battery electric cars can perform just as well or better than gasoline or diesel cars.	0,634
	Cronbach's alpha	**0,761**

Table 3 – EV perception scale: Internal consistency and statistical significance of statements

5.2. H2: Experience with EVs positively impacts knowledge of EVs

To determine whether experience with EVs positively impacted knowledge of EVs an independent T-test analysis was used. People with experience were defined as having either traveled in a hybrid vehicle or BEV. An EV knowledge scale was created by combining four statements from question 10. A reliability analysis was executed resulting in a Cronbach's alpha score of α= 0.828 indicating a high level of internal consistency between the statements (see Table 4). Two statements had a statistical significance of less than 0,05. The data supported the hypothesis that people with experience in an EV also had a higher level of knowledge of EVs. People with experience had a mean score of 3,4 compared to 4,4 for those with no experience, t (68) = 2,804, p= 0,007 (See Appendix 3).

Question / statement	Statement	Significance (2-tailed)
Q10 S3	I know a lot about electric vehicles.	0,022
Q10 S4	I am familiar with the benefits of electric vehicles.	0,053
Q10 S5	I am familiar with the drawbacks of electric vehicles.	0,000
Q10 S8	I am familiar with the electric vehicle incentives in Finland.	0,576
	Cronbach's alpha	**0,828**

Table 4 - EV knowledge scale: Internal consistency and statistical significance of statements

5.3. H3: People with favorable views of EVs also believe the government should play a more active role in increasing EV adoption rates

A scale measuring the degree to which respondents believed the government should be involved in increasing EV adoption rates was created by combining four statements from question 12. Statement 5 was re-coded to make sure all the statements were consistent with each other. A reliability analysis resulted in a Cronbach's alpha of α= 0,612 indicating an acceptable level of internal consistency between the statements (see Table 5).

Pearson's correlation analysis was used to determine whether favorable perceptions were correlated with the belief that the government should be more active in increasing EV adoption rates. The variables were found to be moderately positively correlated, t (67) = 0,481, p= 0,000. A multiple linear regression analysis was also used to determine the degree to which favorable perceptions explained the belief in increased government involvement. This resulted in a regression equation of F (1, 66) = 19,901, p = 0,000, with an R^2 score of 0,232 (see Appendix 4). Therefore, the data supported the hypothesis.

Question / statement	Statement
Q12 S1	I believe the government should incentivise the use of battery electric vehicles more heavily in order to increase adoption rates in Finland.
Q12 S2	I believe the government should disincentivise the use of gasoline cars more heavily in order to promote the use of battery electric vehicles in Finland.
Q12 S4	I believe the government should incentivise the use of all types of electric vehicles and alternative fuel vehicles that lower greenhouse gas emissions.
Q12 S5R	I believe that market forces will make electric vehicles more popular in the near future and therefore their use doesn't need to be incentivised currently. *(re-coded)*
Cronbach's alpha	**0,612**

Table 5 - Government role scale: Internal consistency of statements

6. DISCUSSION

6.1. Discussion on Findings

Some interesting findings were made in this study, some of which were to be expected and others that weren't. Firstly, the development of EV charging infrastructure in Finland was emphasized as a key policy priority. Respondents rated charging infrastructure constraints as the most severe limitation to EV adoption and also rated public charging infrastructure funding as the most appealing incentive policy. This is consistent with findings from earlier research, which suggests improving charging infrastructure is a priority in Finland (Fortum, 2017; Kester et al., 2018; Noel et al., 2019). For example, Noel et al. (2019) found that practicality related attributes are emphasized in the Nordic countries over performance. Furthermore, improved acceleration was rated as the second least appealing benefit of EVs, while attributes like range constraints and slow charging speed were considered severe limitations, which is also consistent with the findings of Noel et al. (2019).

Moreover, the emphasis on improving charging infrastructure is consistent with the findings of Kester et al. (2018) who discovered that improving charging infrastructure in Finland is emphasized because it is seen as an opportunity for local companies as well as a public benefit. Many local companies in Finland are in fact developing the charging infrastructure around the country and unlike financial incentives like purchase grants, which benefit individual EV buyers, everyone stands to benefit from a more developed network of charging stations. However, it is important to note that financial incentives and charging infrastructure have also been shown to be the two best predictors of EV adoption rates generally, so these findings were to be expected (Sierzchula et al., 2014).

Perhaps the most unexpected finding from this study was that respondents didn't seem to consider purchase prices more important than ownership costs, contrary to previous research findings (Larson et al., 2014; Rezvani et al., 2015). This was quantified using multiple different questions. For example, most respondents indicated some level of disagreement when asked if they considered purchase prices more important than ownership costs. Furthermore, lower purchase taxes and in-use taxes were also rated as equally appealing incentive policies. However, when asked if respondents believed that direct financial incentives were more effective at increasing adoption rates most people agreed with this sentiment, which is somewhat inconsistent with the other two findings. Moreover, when asked what would make respondents consider buying a BEV, a lower price was cited most frequently. It is important to note that 55% of respondents didn't own a car and no one owned a BEV, therefore these results may not be representative of people who are actually considering buying a BEV.

6.2. Limitations of Study

This study has numerous limitations that need to be taken into consideration when interpreting the results of this study. Firstly, the sample size was very small (N=71) which made it difficult to make conclusive findings. A larger sample size would have provided more data from which to draw conclusions. There were a few limiting factors in getting people to answer the survey. First of all, only people residing in

Finland were allowed to answer the survey which limited the means in which the survey could be distributed. Secondly, due to the topic of the survey and the use of relatively technical terminology, some people may not have felt comfortable answering the survey due to a lack of knowledge or interest in the topic. Anecdotal evidence from some respondents indicated that this was the case. However, increasing the amount of limiting criteria would have made it even harder to collect data and it would have been difficult to quantify how much knowledge a respondent had regarding EVs for example before answering the survey. Instead, respondents were asked to indicate their level of knowledge and experience with EVs during the survey.

This leads to two other limiting factors with the survey, namely the level of experience and knowledge regarding EVs among the sample of respondents. Only 40% of respondents had traveled in a BEV while 74% had traveled in a hybrid vehicle. Furthermore, only 16% of respondents had driven a BEV and 32% had driven a hybrid vehicle. Therefore, the level of experience with EVs among the sample was quite low. However, this isn’t necessarily bad as it is also important to consider the opinions of those with little to no experience also.

When it came to the knowledge of EVs, the responses were mixed. In general, respondents were more familiar with the benefits of EVs than the drawbacks. The majority of respondents also indicated that they weren’t familiar with the EV incentives in Finland. Therefore, this would indicate that educating consumers is indeed another policy priority as previous research has indicated (Larson et al., 2014; Kester et al., 2018). If consumers aren’t aware of the incentives for EVs or their potential benefits and limitations it makes it less likely that they will choose to adopt them. This presents a potential opportunity for OEMs to better market their products and for the Finnish government to make consumers more aware of the incentives for adopting an EV if they wish to reach their ambitious targets for BEV adoption by 2025.

6.3. Review of the Chosen Methodology

Despite the limitations of the study, the methodology was appropriate. Even though the sample size was small, many important observations could be made. However, in hindsight, there are some aspects that could have been improved. Firstly, the survey could have been shorter. This could have been achieved by eliminating some questions, such as the questions relating to transportation habits, as these weren't directly pertinent to the research questions. Some of the demographic questions could have also been eliminated to make the survey shorter. Furthermore, the survey could have been organized differently with specific sections and all of the statements in the Likert scale questions could have been worded so that they were consistent with each other eliminating the need for re-coding.

6.4. Review of the Chosen Objectives

Regarding the objectives set for this study, they have been achieved adequately. Firstly, the literature review and findings from the survey have provided a better understanding of consumer attitudes and opinions regarding EVs in Finland. Secondly, the primary data collected for the survey has been compared and contrasted with previous research findings. Furthermore, the findings from this study have provided a better understanding of the key measures that need to be implemented to increase EV adoption rates in Finland, providing the Finnish government with policy recommendations.

7. CONCLUSION

7.1. Main Findings

A comprehensive literature review was carried out compiling the current research relating to consumer opinions and attitudes towards EVs. Major obstacles to EV adoption were identified and discussed. The current research indicates that major barriers to EV adoption are the cost premium carried by EVs relative to ICEVs, range constraints, and charging constraints, including slow charging speed and the limitations created by a lack of charging stations. However, this limitation is largely dependent on geographical location. For example, Norway has a much vaster network of charging stations across the country in comparison to Finland. Despite the limitations of EVs, the literature also indicates that EVs have advantages in relation to ICEVs such as a substantially lower environmental impact and potential TCO savings when ownership costs are accounted for.

A survey was conducted to gather information on consumer opinions relating to EVs in Finland. The results indicated that improving charging infrastructure is an apparent priority as charging infrastructure constraints were rated as the most severe limitation of EVs and public charging infrastructure funding was rated as the most appealing policy incentive. This presents an opportunity for the Finnish government as well as private companies to improve the charging infrastructure across the country in order to increase adoption rates. Therefore, increasing the number of charging locations and improving charging speeds are key priorities for increasing adoption rates in Finland.

Two other apparent conclusions can be made based on the findings from this study. Firstly, a more comprehensive policy approach is required to increase adoption rates in Finland. The current policy approach of the Finnish government is focused on making the purchase of a BEV cheaper. A larger emphasis needs to be put on making the ownership of an EV more convenient, an area where Norway in particular has excelled. For example, this can be achieved by offering lower in-use taxes as well as improving charging infrastructure across the country. Secondly, this study highlights the need for consumer education. Both OEMs and governments stand to benefit from better educating consumers on the topic as consumers need to be made aware of the benefits of EV ownership in order for them to consider it as an option.

7.2. Implications for International Business

The global EV market is expanding rapidly. According to the International Energy Agency (2019), EVs will have a global market share of 15% by 2030 up from just 1% in 2018. Competition is also increasing rapidly with major OEMs like Audi, Volkswagen, BMW, Peugeot, and Volvo to name a few, releasing new EV models in 2020 (Autocar, 2020). A market that has been dominated by one single OEM, namely Tesla, will be a lot more competitive in the years to come. Consumers will have a lot more options to choose from as the market is expected to grow exponentially. In many ways, the success of Tesla has forced other OEMs to realize that electric is the future of the automobile industry. This is evident since OEMs across the globe have pledged to spend billions on developing new EV models with the goal of reducing carbon emissions substantially.

For example, Volvo has pledged that half of its cars will be electric by 2025, Mercedes Benz wants half of its car sales to be EVs by 2030, and Toyota has pledged to cut vehicle life-cycle emissions by 25% or more by 2030 (Hawkins, 2019). These are just a few examples, as the industry is set to go through a major shift during the next decade. OEMs will have to be receptive to consumer requirements in order to develop more appealing vehicles. Governments across the globe are also setting ambitious targets for reducing GHG emissions and increasing the amount of EVs, such as the Finnish government. Similar to OEMs, governments also need to have an understanding of what the most effective policies are for increasing adoption rates in order to achieve the targets that have been set. Therefore, OEMs and governments around the world need to have a firm understanding of the research regarding consumer opinions on EVs in different geographical locations.

7.3. Suggestions for Future Research

This study highlights the need for more research into consumer opinions regarding EVs in Finland. While this study has contributed to the literature, more detailed and specific studies are needed to understand how people in Finland view EVs and how adoption rates could be increased. Based on the findings from this study, it would be important to study how charging infrastructure in Finland could be developed most effectively. It would be important to know where the most optimal locations for charging stations should be, what the appropriate role of private companies is in expanding coverage, and what kind of usage pricing schemes would work best.

Furthermore, a more rigorous and comprehensive qualitative study should be carried out to identify how different demographic groups in Finland respond to different policy incentives. For example, it would be interesting to see if people in rural areas place a greater emphasis on improving charging infrastructure as the charging infrastructure in rural areas is less developed than in urban areas. The current literature also clearly indicates that metropolitan areas are more suited for widespread EV adoption. This comparison could not be made in this study due to the low sample size and lack of respondents from rural areas.

Qualitative research should also be carried out to gain a deeper understanding of consumer opinions. People with different levels of knowledge and experience with EVs should be interviewed to see if they view EVs differently. For example, BEV owners in Finland could be interviewed to see how their views have changed on EVs after purchasing their vehicles and what they feel would be the best incentive policies for increasing adoption rates. A case study could also be carried out to see how a new BEV owner adapts to life with the vehicle and whether it changes their views or behavior in some way.

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APPENDICES

Appendix 1: Survey

Electric Vehicles Survey

1. Thank you for taking the time to answer this survey on electric vehicles. This survey will take approximately 7 minutes to complete. The data gathered from this survey will be used for my Bachelor's Thesis regarding consumer opinions on electric vehicles and incentive policies in Finland. Therefore, only people who live in Finland should answer the survey.

This research is being conducted at the Aalto University Mikkeli campus under the supervision of Susan Grinsted Ph.D. The data gathered in this survey will only be used for the purpose of the thesis project. All answers are anonymous and you can exit the survey at any time if you wish. I hope you will complete the survey and thank you for your participation.

If you have any questions regarding the survey or thesis project you can contact me at alex.darlington@aalto.fi.

I consent to the terms and wish to proceed with the survey. *

- ◯ Agree

2. What is your country of residence? *

- ◯ Finland
- ◯ Other

3. I own one of the following types of vehicles (check all that apply).

- ☐ Internal Combustion Engine Vehicle (eg. gasoline or diesel car)
- ☐ Battery Electric Vehicle (fully electric car)
- ☐ Hybrid vehicle
- ☐ Other type of vehicle (eg. biofuel or hydrogen car)
- ☐ I don't own a car

4. I have traveled in one of the following types of vehicles (check all that apply).

- ☐ Internal Combustion Engine Vehicle (eg. gasoline or diesel car)
- ☐ Battery Electric Vehicle (fully electric car)
- ☐ Hybrid vehicle

- [ ] Other type of vehicle (eg. biofuel or hydrogen car)

5. I have driven one of the following types of vehicles (check all that apply).

- [ ] Internal Combustion Engine Vehicle (eg. gasoline or diesel car)
- [ ] Battery Electric Vehicle (fully electric car)
- [ ] Hybrid vehicle
- [ ] Other type of vehicle (eg. biofuel or hydrogen car)

6. I would consider buying one of the following types of vehicles in the future (check all that apply).

- [ ] Internal Combustion Engine Vehicle (eg. gasoline or diesel car)
- [ ] Battery Electric Vehicle (fully electric car)
- [ ] Hybrid vehicle
- [ ] Other type of vehicle (eg. biofuel or hydrogen car)

7. I'm looking to buy a car within the next....

- ◯ year
- ◯ 1-2 years
- ◯ 2-4 years
- ◯ 4-7 years
- ◯ 7-10 years
- ◯ I'm not planning on buying a car

8. How many days per week do you drive a car on average?

- ◯ 0
- ◯ 0-2
- ◯ 2-4
- ◯ 4-6
- ◯ 6 or more

9. My main form of daily transportation is....

- ◯ a car
- ◯ an other vehicle
- ◯ public transport
- ◯ walking
- ◯ biking
- ◯ carpooling
- ◯ other

10. Please indicate whether you agree of disagree with the following statements.

	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
I have a favorable view of electric vehicles.	◯	◯	◯	◯	◯	◯	◯
I perceive electric vehicles to be environmentally friendly.	◯	◯	◯	◯	◯	◯	◯
I know a lot about electric vehicles.	◯	◯	◯	◯	◯	◯	◯
I am familiar with the benefits of electric vehicles.	◯	◯	◯	◯	◯	◯	◯
I am familiar with the drawbacks of electric vehicles.	◯	◯	◯	◯	◯	◯	◯
I believe a fully electric vehicle could meet the majority of my travel needs.	◯	◯	◯	◯	◯	◯	◯

	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
I consider the purchase price of a vehicle to be more important than the ownership costs.	◯	◯	◯	◯	◯	◯	◯
I am familiar with the electric vehicle incentives in Finland.	◯	◯	◯	◯	◯	◯	◯
I perceive battery electric cars to be less practical than gasoline or diesel cars.	◯	◯	◯	◯	◯	◯	◯
Battery electric cars can be just as visually appealing as gasoline or diesel cars.	◯	◯	◯	◯	◯	◯	◯
Battery electric cars can perform just as well or better than gasoline or diesel cars.	◯	◯	◯	◯	◯	◯	◯

11. Between 2018-2021 the buyer of a battery electric vehicle in Finland can receive a government grant towards the purchase of a vehicle provided that certain requirements are met. What is the size of this government grant? (don't guess if you don't know)

◯ 500 euros
◯ 1000 euros
◯ 1750 euros
◯ 2000 euros
◯ 3500 euros
◯ I don't know

12. In 2018, electric vehicles had a market share of 4.7% in Finland compared to 46.4% in Norway. Furthermore, hybrid vehicles account for more than 95% of the Finnish electric vehicle market whereas in Norway battery electric vehicles account for more than 50% of the electric vehicle market.

Due to the nature of Finnish energy production, battery electric vehicles have a lower carbon footprint than internal combustion engine vehicles. Furthermore, BEVs don't produce any local air pollutants or noise pollution.

Based on this information, please indicate whether you agree or disagree with the following statements.

	Strongly agree	Agree	Somewhat agree	Neutral	Somewhat disagree	Disagree	Strongly disagree
I believe the government should incentivise the use of battery electric vehicles more heavily in order to increase adoption rates in Finland.	○	○	○	○	○	○	○
I believe the government should disincentivise the use of gasoline cars more heavily in order to promote the use of battery electric vehicles in Finland.	○	○	○	○	○	○	○
I believe that direct financial incentives aimed at lowering purchase prices (lower taxes, subsidies, and grants) would be more effective at increasing adoption rates than providing benefits aimed at lowering ownership costs (eg. access to bus lanes and parking benefits).	○	○	○	○	○	○	○
I believe the government should incentivise the use of all types of electric vehicles and alternative fuel vehicles that lower greenhouse gas emissions.	○	○	○	○	○	○	○
I believe that market forces will make electric vehicles more popular in the near future and therefore their use doesn't need to be incentivised currently.	○	○	○	○	○	○	○

13. Rate the appeal of these electric vehicle incentive policies for you personally with 7 indicating the highest level of attractiveness.

	1	2	3	4	5	6	7
Lower tax/ grant towards the purchase price	○	○	○	○	○	○	○
Lower in-use taxes	○	○	○	○	○	○	○

	1	2	3	4	5	6	7
Lower parking fees	○	○	○	○	○	○	○
Other parking benefits (eg. more parking spaces for EVs)	○	○	○	○	○	○	○
Subsidised electricity costs (lower charging costs)	○	○	○	○	○	○	○
Public charging infrastructure funding	○	○	○	○	○	○	○
Access to bus lanes	○	○	○	○	○	○	○

14. I would be willing to pay (insert answer) for an electric vehicle compared to a similar gasoline or diesel car.

- ○ >20% less
- ○ 10-20% less
- ○ the same
- ○ 10-20% more
- ○ 20-50% more
- ○ >50 % more

15. I am familiar with the term vehicle-to-grid (V2G) and know what it means.

- ○ Yes
- ○ No

16. Rate the importance of these major benefits associated with electric vehicles with 7 indicating the highest level of importance.

	1	2	3	4	5	6	7
Eco-friendliness (reduced greenhouse gas emissions)	○	○	○	○	○	○	○
Reduced air pollution	○	○	○	○	○	○	○
Reduced noise pollution	○	○	○	○	○	○	○
Lower maintenance costs	○	○	○	○	○	○	○
Lower fuel (electricity) costs	○	○	○	○	○	○	○

	1	2	3	4	5	6	7
Ability to charge vehicle at home	○	○	○	○	○	○	○
Improved acceleration	○	○	○	○	○	○	○
Vehicle-to-grid capability	○	○	○	○	○	○	○

17. Rate the severity of these major drawbacks associated with electric vehicles with 7 indicating the highest level of severity.

	1	2	3	4	5	6	7
Range constraints	○	○	○	○	○	○	○
Higher purchase price	○	○	○	○	○	○	○
Slow charging speed	○	○	○	○	○	○	○
Charging infrastructure constraints	○	○	○	○	○	○	○
Lower resale value	○	○	○	○	○	○	○
Battery degradation	○	○	○	○	○	○	○
Concern over battery waste at the end of life cycle	○	○	○	○	○	○	○

18. When looking at the total cost of ownership, including purchase price and ownership costs, I would need to save money within (insert answer) in order to consider buying an electric vehicle.

- ○ 0-1 year
- ○ 1-3 years
- ○ 3-5 years
- ○ 5-10 years
- ○ >10 years
- ○ I don't need to save money
- ○ I wouldn't consider an electric vehicle in any case

19. In a study conducted by Mellinger et al. (2018) the authors found that battery electric vehicles could already cover 85-90% of trips within Finland in 2017. How far would a battery electric vehicle have to travel on a single charge to meet 90% of your requirements?

- ○ 50-100 km

- 100-200 km
- 200- 300 km
- 300- 400 km
- 400- 500 km
- >500 km

20. What would make you consider buying a BEV (fully electric vehicle) in the future? [short answer]

21. What is your country of origin (nationality)?

- Afghanistan
- Albania
- Algeria
- Andorra
- Angola
- Antigua and Barbuda
- Argentina
- Armenia
- Australia
- Austria
- Azerbaijan
- Bahamas
- Bahrain
- Bangladesh
- Barbados
- Belarus
- Belgium

- ◯ Belize
- ◯ Benin
- ◯ Bhutan
- ◯ Bolivia
- ◯ Bosnia and Herzegovina
- ◯ Botswana
- ◯ Brazil
- ◯ Brunei
- ◯ Bulgaria
- ◯ Burkina Faso
- ◯ Burundi
- ◯ Cabo Verde
- ◯ Cambodia
- ◯ Cameroon
- ◯ Canada
- ◯ Central African Republic (CAR)
- ◯ Chad
- ◯ Chile
- ◯ China
- ◯ Colombia
- ◯ Comoros
- ◯ Congo
- ◯ Costa Rica
- ◯ Cote d'Ivoire
- ◯ Croatia
- ◯ Cuba
- ◯ Cyprus
- ◯ Czechia
- ◯ Denmark
- ◯ Djibouti
- ◯ Dominica
- ◯ Dominican Republic

- Ecuador
- Egypt
- El Salvador
- Equatorial Guinea
- Eritrea
- Estonia
- Eswatini (formerly Swaziland)
- Ethiopia
- Fiji
- Finland
- France
- Gabon
- Gambia
- Georgia
- Germany
- Ghana
- Greece
- Grenada
- Guatemala
- Guinea
- Guinea-Bissau
- Guyana
- Haiti
- Honduras
- Hungary
- Iceland
- India
- Indonesia
- Iran
- Iraq
- Ireland
- Israel

- Italy
- Jamaica
- Japan
- Jordan
- Kazakhstan
- Kenya
- Kiribati
- Kosovo
- Kuwait
- Kyrgyzstan
- Laos
- Latvia
- Lebanon
- Lesotho
- Liberia
- Libya
- Liechtenstein
- Lithuania
- Luxembourg
- Madagascar
- Malawi
- Malaysia
- Maldives
- Mali
- Malta
- Marshall Islands
- Mauritania
- Mauritius
- Mexico
- Micronesia
- Moldova
- Monaco

- Mongolia
- Montenegro
- Morocco
- Mozambique
- Myanmar (formerly Burma)
- Namibia
- Nauru
- Nepal
- Netherlands
- New Zealand
- Nicaragua
- Niger
- Nigeria
- North Korea
- North Macedonia (formerly Macedonia)
- Norway
- Oman
- Pakistan
- Palau
- Palestine
- Panama
- Papua New Guinea
- Paraguay
- Peru
- Philippines
- Poland
- Portugal
- Qatar
- Romania
- Russia
- Rwanda
- Saint Kitts and Nevis

- Saint Lucia
- Saint Vincent and the Grenadines
- Samoa
- San Marino
- Sao Tome and Principe
- Saudi Arabia
- Senegal
- Serbia
- Seychelles
- Sierra Leone
- Singapore
- Slovakia
- Slovenia
- Solomon Islands
- Somalia
- South Africa
- South Korea
- South Sudan
- Spain
- Sri Lanka
- Sudan
- Suriname
- Sweden
- Switzerland
- Syria
- Taiwan
- Tajikistan
- Tanzania
- Thailand
- Timor-Leste
- Togo
- Tonga

- Trinidad and Tobago
- Tunisia
- Turkey
- Turkmenistan
- Tuvalu
- Uganda
- Ukraine
- United Arab Emirates (UAE)
- United Kingdom (UK)
- United States of America (USA)
- Uruguay
- Uzbekistan
- Vanuatu
- Vatican City (Holy See)
- Venezuela
- Vietnam
- Yemen
- Zambia
- Zimbabwe

22. What is your age?

- <18
- 18-21
- 22-25
- 26-30
- 31-40
- 41-55
- >55

23. What is your gender?

- ◯ Male
- ◯ Female
- ◯ Prefer not to say

24. Are you a student and/or employed?

- ◯ Neither
- ◯ Student
- ◯ Employed (part or full-time)
- ◯ Both

25. What is your education level?

- ◯ Less than high school education
- ◯ High school education
- ◯ University/ college student, no degree
- ◯ Bachelor's degree
- ◯ Master's degree
- ◯ Doctorate degree (Ph.D.)
- ◯ Vocational education
- ◯ Other

26. What is your personal annual estimated income level (€)?

- ◯ 0-10 000
- ◯ 10 000 - 20 000
- ◯ 20 000 - 30 000
- ◯ 30 000 - 40 000
- ◯ 40 000 - 50 000
- ◯ 50 000 - 60 000
- ◯ 60 000 - 70 000
- ◯ 70 000+

27. What type of area do you live in?

- ◯ Urban
- ◯ Suburban
- ◯ Rural

Appendix 2: Hypothesis 1 SPSS Figures

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EV_PERCEPTIONS average 1,2,6,9R, 10, 11	Equal variances assumed	.452	.504	-.169	67	.867	-.04785	.28370	-.61412	.51843
	Equal variances not assumed			-.176	18.976	.862	-.04785	.27135	-.61585	.52015

Group Statistics

	have they travelled in batt or hybrid vehicle	N	Mean	Std. Deviation	Std. Error Mean
EV_PERCEPTIONS average 1,2,6,9R, 10, 11	.00	13	2.7051	.86910	.24105
	1.00	56	2.7530	.93257	.12462

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EV_PERCEPTIONS average 1,2,6,9R, 10, 11	Equal variances assumed	4.469	.038	1.674	67	.099	.37050	.22139	-.07140	.81240
	Equal variances not assumed			1.768	66.442	.082	.37050	.20957	-.04787	.78887

Group Statistics

	I have traveled in one of the following types of vehicles (check all that apply).:Battery Electric Vehicle (fully electric car)	N	Mean	Std. Deviation	Std. Error Mean
EV_PERCEPTIONS average 1,2,6,9R, 10, 11	.00	41	2.8943	.99705	.15571
	1.00	28	2.5238	.74219	.14026

Appendix 3: Hypothesis 2 SPSS Figures

Group Statistics

	have they travelled in batt or hybrid vehicle	N	Mean	Std. Deviation	Std. Error Mean
EV_Knowledge	.00	13	4.3846	1.05877	.29365
	1.00	57	3.3816	1.18501	.15696

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EV_Knowledge	Equal variances assumed	.081	.777	2.804	68	.007	1.00304	.35768	.28930	1.71677
	Equal variances not assumed			3.012	19.495	.007	1.00304	.33297	.30733	1.69875

Appendix 4: Hypothesis 3 SPSS Figures

Correlations

		EV_PERCEPTIONS average 1,2,6,9R, 10, 11	Government_role
EV_PERCEPTIONS average 1,2,6,9R, 10, 11	Pearson Correlation	1	.481**
	Sig. (2-tailed)		.000
	N	70	68
Government_role	Pearson Correlation	.481**	1
	Sig. (2-tailed)	.000	
	N	68	69

**. Correlation is significant at the 0.01 level (2-tailed).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.481[a]	.232	.220	.85265

a. Predictors: (Constant), EV_PERCEPTIONS average 1,2,6,9R, 10, 11

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.468	1	14.468	19.901	.000[b]
	Residual	47.983	66	.727		
	Total	62.451	67			

a. Dependent Variable: Government_role

b. Predictors: (Constant), EV_PERCEPTIONS average 1,2,6,9R, 10, 11