Factors Influencing the Adoption of Electric Vehicles in the Netherlands

Master Thesis

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Preface

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Abstract

Countries all over the world are trying to tackle the problem of global warming. The claim that human activities significantly contribute to this phenomenon has forced governments to rethink their green agenda. The transportation sector is a big contributor to the greenhouse gas effect and is therefore under increasing pressure to change. The clear alternative for fossil-fuel cars is the electric vehicle, as it produces no harmful pollutants through the tailpipe. The Netherlands has decided to push for a green revolution and has communicated the ambitious goal of 1 million (H)EVs in 2025. However, while the numbers of EVs is growing, it is still very far away from the desired mass adoption. Consumers are still buying ICEs over EVs. What factors influence the rate of EV adoption in The Netherlands?

In this paper, we present the findings of a survey conducted on 173 respondents living in the Netherlands. There is a total of 10 factors hypothesized to influence the purchasing behavior of consumers. The study aims to give insight into which of these 10 factors is most influential and to what extent. A hierarchical multiple regression is used to analyze the data and find how much of the variance can be explained by each variable.

The findings show that there are three factors influencing EV adoption of which two are clearly the most influential. They are, in descending order of importance: charging station accessibility ($\beta = 0.255, p < 0.05$), range anxiety ($\beta = -0.227, p < 0.05$) and belief in EV technology ($\beta = 0.191, p < 0.05$). These results are consistent with the literature. The other hypotheses are not supported. The factors that are not significant predictors of EV adoption are sustainability ($\beta = 0.122, p = 0.09$), price ($\beta = -0.012, p = 0.857$), fossil-fuel critical ($\beta = 0.011, p = 0.866$), experience ($\beta = 0.075, p = 0.286$), social reinforcement ($\beta = 0.061, p = 0.401$), identity ($\beta = -0.003, p = 0.963$) and negative perception ($\beta = -0.026, p = 0.717$). As some results are surprising, alternate explanations are presented.

The key influencing factor, charging station accessibility, needs to be addressed. There are many consumers who have no private parking space. The lack of public charging spaces directly prevents those consumers from considering an EV. The business case for charging stations is negative however due to EV still being in its beginning phase. Here is an important role for the government. Through increasing public charging stations, the second key factor: range anxiety, is also addressed as it decreases when there is good public charging coverage. This will in turn facilitate the switch to EV adoption making the business case for charging stations positive due to a bigger market.
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1. Introduction

Climate change has received a lot of attention in the current year 2017. Barack Obama declared a US$500 million grant to the Green Climate Fund a few days before President-elect Donald Trump took over his position. The grant was the second $500 million instalment of a total $3 billion that the US had agreed to contribute when signing the Paris Climate Agreement in 2015. The Obama administration was called on by many to transfer all instalments at once, as people feared that Trump would not honor the commitment (Guardian, 2017). Following Trump’s arrival, all mentions of climate change had been removed from the White House website. This sparked a major concern among climate scientists that the president of the US does not believe in a phenomenon that has been supported by science with clear evidence. As of August 2017 the U.S. Department of State has released an official press release stating the intent to withdraw from the Paris Agreement (U.S. Department of State, 2017).

Scientists have been able to collect a wide variety of information about the earth and its climate change due to technological advances. Ever since the 19th century we have known that gases such as carbon dioxide have the ability to trap heat. It is only logical that an increase in these types of gases result in an increase in the temperature on earth (Global Climate Change: Evidence, 2008). The notion that greenhouse gas levels influence the climate is supported by inspecting ice cores in Greenland and Antarctica. Similar evidence can be drawn from sedimentary rocks, tree rings and ocean sediments, to name a few. A troubling finding is that this warming process is happening with an average rate that is ten times as fast as the warming that occurred during the ice-age recovery period (NRC, 2006). There are several indicators of climate change that are occurring simultaneously. For starters, the global temperature has risen. 2015 was the first year that showed average temperatures higher than the average in 1880-1899, when record tracking started. 15 of the 16 warmest years on record have occurred since 2001 (Peterson et al., 2009). This also results in the oceans becoming warmer, as they absorb some of the heat. After 1969, the top 700 meters of ocean has become 0.302 degrees Fahrenheit warmer (Levitus et al., 2009). This has consequences for the ice in the Arctic sea. According to Polyak, et al., (2009), the ice has seen rapid declines. Not only the ice in the Arctic sea suffers from climate change, also in Greenland and Antarctica ice sheets show a loss of mass. Even the glaciers on top of mountains such as the Himalayas and Alps are diminishing (Oerlemans, 2001). The melting of ice results in a rise of the sea level. A 17 centimeter rise has been found over the last decade, while the last decade showed a decrease rate that is almost double as fast compared to the rate of last century (Church & White, 2006).
different problem linked to greenhouse gas is the acidification of our oceans. Carbon dioxide emissions result in a chemical change of the oceans, as it absorbs some of the CO\textsubscript{2}. Initially, scientists looked at this construct as something positive, however now it is said that it could have negative effects on life in the ocean, as food webs could be impacted (PMEL, 2017).

97% of climate scientists support the claim that human activities significantly contribute to climate warming. The intergovernmental Panel on Climate Change goes as far as saying the scientific evidence is unequivocal. In March 2015, carbon dioxide levels in our atmosphere reached 400 parts per million for the first time. It has increased from 280 to 400 over the last 150 years (Global Climate Change: Evidence, 2008).

Human activities resulted in a total of almost 46 billion metric tons of greenhouse gases (as carbon dioxide equivalents expressed) in 2010. Compared to 1990, the emission has grown by 35%. Use and production of energy, such as fuels used by vehicles, resulted in the majority (71%) of greenhouse gas emissions (CAIT, 2014).

Changes on the environment of earth are appearing with effects that are irreversible if we do not slow fossil fuel emission in the next few decades (Hansen, 2009). Climate change is a problem that can only be addressed by collective action at a global scale. Emissions of greenhouse gases by any country will affect other countries as gases accumulate and mix globally over time. Mitigation is not effective if countries operate independently, it needs a cooperative response. An involvement of all countries poses problems, as some countries are in very different states of technological advancements. Some countries have only recently undergone strong economic developments and
less receptive for claims to protect the environment. Competition is a driving factor in this. In a recent paper written by Barack Obama for Science magazine he attempts to debunk the notion that fighting climate change requires the acceptance of lower economic growth or a decreased standard of living (Obama, 2017). The US has cut CO2 emissions by 9.5% from 2008 to 2015, while the country’s economy experienced a growth of 10%. He argues that even though this decoupling of the energy sector emissions and economic growth is most prevalent in the US, other economies around the world also show that it is possible.

On December 12, 2015 the Paris Agreement was signed by 196 parties. This legally-binding framework has been set to tackle climate change. The idea behind the agreement is that by setting a collective ambitious target and increasing transparency, countries will step up and partake individually by pledging reduced emissions. Only the elements of the actual pact are legally binding. The Kyoto Protocol from 1997 failed miserably as the USA retracted itself and other countries failed to adhere to the agreement as well. It was feared that individual countries will not take action while support amongst countries is lacking. Therefore the plan was for developed countries to support less-developed countries with financing so that they have the financial funds to make a switch to greener alternatives (UNFCC, 2015). During the recent climate meeting in Marrakesh, the fact that 110 countries, good for more than 75% of global emissions, have chosen to partake in the Paris Agreement, the momentum is irreversible for the fight against climate change (Obama, 2017).

Not paying any attention to carbon pollution will impose tremendous costs to the global economy and as a long-term result will be bad for jobs and growth. Having the earth warm up by 4 °C over preindustrial levels is expected to result in economic damages that range from 1% to 5% of global GDP per year by the year 2100 (Nordhaus, 2013). These damages will be much more costly than the transition towards greener alternatives.

Until recently, countries, firms and individuals mostly invested in renewable energy due to being environmentally driven. They accepted paying more money or having higher costs if it resulted in not having to use environmentally unfriendly fossil fuels. However, due to technological advancements and economies of scale, we have reached a turning point. In previous years, solar energy could only compete with coal due to heavy subsidization. Isolated projects, such as an enormous solar power farm in the Middle East, one in India and one in Chile already showed a lower cost for solar energy. Renewables have now started to undercut the price of fossil fuels and the expectation is that this will only improve (Bloomberg, 2016).
The transportation sector is a big culprit in the global warming discussion. The use of fossil fuels brings about large environmental cost as it is a massive contributor to the greenhouse gas effect (Rolim et al., 2012). As of 2010, there are more than 1 billion motor vehicles globally (Sousanis, 2011). The transport sector is accountable for 23% of global energy-related greenhouse gas emissions (IEA, 2015b). The emissions reduction required to limit global warming to less than 2°C is very difficult to achieve if the transport sector does not cooperate. For these reasons, alternative vehicle technologies are pursued with interest.

The clear alternative for fossil-fuel cars is the electric vehicle (EV). They are considerably better for the environment as they have a higher energy efficiency when compared to fossil-fuel vehicles (Blok, 2007). Fossil-fuel vehicles convert a lot of energy into heat. This is a problem electric motors do not have. EVs reach efficiencies of over 90% (The Engineering Toolbox, 2016), while fossil-fuel cars reach around 25% for gasoline and 30% for diesel cars (Blok, 2007). It has to be said that the sustainability of EVs is largely dependent on the method of energy generation. However, even when an EV is charged through coal-generated energy, it still reaches higher total energy efficiency than a fossil-fueled car (Blok, 2007). Other advantages such regaining energy through regenerative breaking help as well.

Fossil-fuel cars produce harmful pollutants such as nitrogen oxides through the tailpipe. EVs produce zero direct emissions. This does not just counter climate change, it also helps improve air quality especially in urban areas (Energy.gov, 2017).

A possible environmentally harmful consequence of EVs can be found by looking at the grid. If the adoption of EVs results in too much stress on the grid, as many EVs are charged during peak times, then the grid has to be expanded resulting in infrastructural investments. When looking at environmental damages, the production process of an EV should not be forgotten. Over 1/3 of the CO₂ emission taking place during an EVs lifecycle happens during the production process. The battery is a particularly harmful part to produce (Copenhagen Consensus Center, 2016).

We generally distinguish the following vehicle types (US Department of Energy, 2013):  

**ICE:** The traditional Internal Combustion Engine vehicle generates power by burning liquid fuel such as diesel or gasoline. ICEs can be fueled by fossil fuels or bio-fuel. Bio-fuel is a more environmentally friendly alternative. In practice it poses problems as large amounts of bio-fuel, often made from corn, are needed.
**BEV:** These are completely electric vehicles that are powered by an electric motor. Energy is stored in a battery that can be charged by plugging it into an off-board source.

**HEV:** Hybrid electric vehicles are powered by an ICE as well as an electric motor. The difference with PHEV is that this car cannot be charged by plugging it into an off-board source. Instead, the battery charges by regenerative breaking or through the ICE.

**PHEV:** Similar to HEV with the exception that this car can be charged by plugging it in (US Department of Energy, 2013).

Currently, the market share is still heavily dominated by ICEs. EVs only account for 0.1% of the total car market (IEA, 2016). When it comes to 2-wheelers, 10% are electric. This is mostly due to electric 2-wheelers being popular in China. They went from a 1% market share in 2001 to 40% now. The current statistics on EVs may look underwhelming, however the future seems bright. Between 2014 and 2015 a 70% increase in new EV registrations was found. Over 550,000 EVs were sold in 2015 as a whole. In the Netherlands, EV market share climbed to 10% while sales doubled. The Dutch market share for EVs is now the second highest in Europe and globally, after Norway with 23% EVs. Other countries like Germany, Sweden, Korea, UK, India and Norway also experienced a year-on-year sales growth of over 75%. Only in the US and Japan there was no growth.

Countries all over the world are currently showing their intentions of taking part in the switch from fossil-fuel car to EV. Britain claimed it would end all sales of fossil-fuel cars by 2040 after France expressed similar ambitions (Phys.org, 2017). China requires 12 percent of all sold vehicles to be fully electric or hybrid by 2020. Even India stated it wants to replace all fossil-fuel cars with electric vehicles by 2030. Norway, Finland and Sweden have made similar statements.

These claims were all done by governments. If the consumers are favoring fossil-fuel vehicles, how feasible are these goals? It is true that we have seen an increase in market share in favor of EVs, however the absolute numbers sold of EVs is still very small compared to fossil-fuel cars, even in countries where EVs are subsidized. Consumers are influenced by a lot of factors when choosing to buy a new car. The aim of this study is to gain insight into the current views of citizens of the Netherlands regarding EVs. The research question can be formulated as follows:

“*What factors influence the rate of EV adoption in The Netherlands?”*
There have been studies that looked at the adoption rate of EVs before. However, most of these studies have been performed in the United States (Jenn et al. 2013, Diamond 2009, Gallagher and Muehlegger 2008). It is not clear whether the results from these studies are transferable to other countries and therefore should be used as indications of potentially relevant market segments (Lieven et al. 2011). Lieven et al. (2011) conducted research in Germany, which is more similar to the Dutch market. This study was done on early adopters of EVs, which will undoubtedly influence the results. It will be interesting to see how the opinions have changed over time, as the landscape, technology and therefore attractiveness of EVs has changed. Studies on EV adoption rates in the Netherlands have been performed by Nedeczky. (2016), Wilmink, (2015), and Bockarjova et al. (2013). While Bockarjova et al. (2013) did their data collection over 4 years ago, the other two are recent. However, these studies differ from this research in methodology and content, as one performed a multiple-case study supplemented with interviews, the other conducted a scenario with the stated choice method. This study does not use either of these methods. The study will help to confirm whether or not known concepts such as range anxiety and sustainability are as much of an influence in the Netherlands as they are in other countries when it comes to EV adoption. Furthermore, it will study other factors that have some basis in the literature, but have not yet been studied as a potential predictor of EV adoption, such as the factor identity. The unique set of predictor variables that are researched helps to fill the literature gap.

This research will help gaining insight into the current views of citizens of the Netherlands regarding EVs. This will make it easier to create effective policy measures regarding EVs and the infrastructure needed to obtain the goals set by governments. The results can help formulate effective strategies to popularize EVs among consumers, as it will show why certain people do or do not want to drive an EV. It will not only give insights into what factors are most important, but also the extent of their strength.
2. Theory development

In this chapter the current literature on EV adoption is reviewed. After discussing a factor of interest, a hypothesis will be formulated on the relation between said factor and EV adoption.

According to a recent study done in The Netherlands by (Ecofys, 2016), plug-in hybrid vehicles with a limited battery capacity should, from a total cost of ownership perspective, lose popularity quickly. This is the case because the Dutch government is reducing tax incentives for hybrids. Furthermore, due to the quickly decreasing battery costs the hybrids can soon not compete anymore with BEVs from a cost perspective. For convenience purposes it is expected that consumers will still consider them. However, in this study we focus on all-electric BEVs as factors like range anxiety are expected to be more measurable due to the lack of an ICE.

The adoption of EVs is largely driven by three factors. These are government stimuli, industry developments and consumer demand (McKinsey, 2014). Stimulating EVs through policy support is a strong driver for growth. One can distinguish two types: technology push and market pull policies. Market pull policies can substantially increase the cost-effectiveness of EVs for consumers. Examples are regulatory measures, financial levers such as differentiated vehicle taxation or other systems like waivers on parking fees. Purchase incentives are the most effective when it comes to pushing EV sales (Searle & Lutsey, 2014). Many countries also employ circulation incentives. An example is the tax paying exemption for zero-emission cars in the Netherlands (IEA, 2016).

Nearly all major car manufacturers now launched their own EVs. The diversity between EV cars has increased, thereby serving a variety of consumer segments. Due to economies of scale the cost for EVs as well as its charging infrastructure has decreased. The most expensive part of the EV, the battery, has seen clear technological improvements, thereby making it cheaper, lighter and giving it a bigger range (McKinsey, 2014). The aforementioned advancements have a positive effect on the demand. It alleviates some of the big concerns consumers have. The biggest pain-points are range anxiety, high costs and low awareness. Range anxiety is experienced as the user knows that the car can only drive a limited distance before the battery depletes. Other problems are the weight of the battery making the car heavy and its price (Argueta and Holms, 2010).

Price

Technological developments as well as economies of scale help with solving these roadblocks. Battery costs have been cut by a factor four since 2008 and the battery range of EVs has increased
tremendously (IEA, 2016). Analysts make wild suggestions about future price competitiveness of EVs compared to ICEs. There are those who believe that within a decade EVs will cost as much as an ICE (BNEF, 2016). Tesla seems to get closer and closer to the very competitive $35,000 price-tag it is targeting for its Model 3. Tesla’s Gigafactory strongly contributes to this, as it enables them to reach even more economies of scale when it comes to producing the costliest part of the car: the battery (Futurism, 2017). Price is an important factor when choosing an EV according to Lieven et al. (2011). A study by Lane and Potter (2007), states that upfront purchase price is a deciding factor in determining vehicle acceptance. This is confirmed by Hidrue et al. (2011), who finds that purchase price is one of the main concerns leading to purchase of EVs. We hypothesize that:

**H1: Price has a negative effect on EV adoption likelihood**

**Charging station accessibility**
Charging stations are absolutely essential to an EV owner. Without a charging station you cannot charge your battery. Public charging stations are very important. They improve the range confidence for EV drivers. They also provide charging opportunities for those who do not have a possibility to install a charging station at home. Especially in the city this is prevalent due to space limits. There are several barriers for public charging stations such as regulatory uncertainty, a lack of standardization and most of all high cost. This is where there is an important role for the government. The government is a party that can investment in EV infrastructure, even when the business case is not yet positive. If there are ample charging stations, EV adoption rates will rise. If there are no charging stations, there will be no rise in EVs. Governments are driven by the desire to have greater energy independence and the possibility of technology ownership (McKinsey 2014).

Easy charging station accessibility appears to be essential for EV adoption. Findings by Dagsvik et al. (2002) show that EVs will only be able to compete with ICEs if the charging infrastructure is there. The study by Silvester et al. (2013) confirms these claims and adds the infrastructure is crucial to deployment of electric mobility. Therefore, we hypothesize that:

**H2: Charging station accessibility has a positive effect on EV adoption likelihood**

**Sustainability**
One of the main reasons to choose an EV over an ICE is the fact that EVs produce zero emissions. Chen et al. (2016) reports that the environmental attitudes of consumers have a strong influence on the intent to buy alternative fuel vehicles. This was confirmed by many other studies. These studies all state that a person’s environmental concerns has an effect on their purchasing behavior when it comes to buying environmentally safe products (Balderjahn, 1988; Ellen et al., 1991; Martin and
Simintiras, 1995; Roberts and Bacon, 1997). The study of Graham-Rowe et al. (2012) even claims that when driving an EV, participants experienced a “feel-good factor” due to the participant’s awareness of the environmental benefits of the EV. For those reasons we hypothesize that:

**H3: Sustainability has a positive effect on EV adoption likelihood**

**Fossil-fuel critical**

One could argue that the world slowly but surely heading towards complete depletion of fossil-fuel resources. As a country without natural oil reserves, the Netherlands is dependent on the market. The Organization of Petroleum Exporting Countries benefits if oil producing countries all reduce production simultaneously. This way if supply of oil is controlled and limited, prices will increase. Europe receives most of its oil from Russia. However, the relationship with Russia has suffered from the annexation of Crimea by the Russian Federation in 2014. Sanctions back and forth have damaged relationships. Russia’s state-run gas monopoly Gazprom recently warned European citizens that sanctions imposed by the USA pose a threat to Europe’s gas supply (Newsweek, 2017). Transportation is a vital aspect of most people’s lives. This means that countries and people are very dependent on oil. Over the years there have been many oil crises, showing how unstable the business is. Prices and availability of oil are very much influenced by politics. When driving an EV, one reduces risks of being a victim of sudden rising oil prices. Dependency on politics and markets is reduced. This way of thinking could push individuals towards buying an EV, thus, we hypothesize that:

**H4: Fossil-fuel critical has a positive effect on EV adoption likelihood**

**Range anxiety**

Range anxiety is defined as “the fear of fully depleting a BEVs battery in the middle of a trip, leaving the driver stranded” (Neubauer & Wood, 2014). Range anxiety increases due to uncertainty. When drivers are inexperienced, unsure about the trip length or energy consumption for heating or cooling the car, it is hard for them to guess how long their battery will last. Range anxiety is reduced by decreasing the uncertainty. Increasing the battery size and the possibilities for recharging while on the road are examples of this.

From the literature it is clear that limited range is a barrier for EV adoption. Bühler et al. (2014) claims that range problems decline when experience go up, however Jensen et al. (2013) shows that range even increases in importance after testing an EV. The study of Franke & Krems (2013) confirms that range anxiety is a persisting problem, as perception of range remains a great barrier
for acceptance even with experienced EV drivers. The study of Hidrue et al. (2011) named range anxiety to be one of the main concerns of consumers. Therefore, we hypothesize that:

*H5: Range Anxiety has a negative effect on EV adoption likelihood*

**Experience**

The effect of experience on the acceptance of EVs has been studied before. Skippon and Garwood (2011) and Graham-Rowe et al. (2012) performed a study where participants tested an EV for 7 days. Results were mixed. Participants were skeptical about whether or not EVs are suitable for daily use, therefore they were considering an EV as a second car. Most participants mentioned they felt good about the environmental benefits. According to Carroll (2010), participants were more positive about EVs after testing them for 1-4 weeks. Turrentine et al. (2011) is in agreement with this. After leasing EVs for one year, drivers have higher opinions as well as increased intentions to purchase an EV. There are not many studies that actually performed a comparison between before situation and after gaining experience. The study of Carroll (2010) reports that after testing an EV, drivers were more willing to use them. Gärling & Johansson (1999) reports that experience has a positive influence on acceptance. Finally, Bühler et al. (2014) finds that perception of EVs advantages and barriers can significantly change when experience is gained, this effect can be in positive as well as negative in directions. Finally, a study done by Jensen et al. (2014) in Denmark found that people with experience showed lower concerns for range anxiety and charging problems. This could potentially increase EV adoption making our hypothesis as follows:

*H6: Experience has a positive effect on EV adoption likelihood*

**Belief in EV technology**

According to a study of Egbue & Long (2012), participants referred to EVs as the future of transportation. They called it “the way of the future” and “future of travel”. These were found to be positive associations. People generally are excited to learn new technologies (Jabeen et al., 2012). For these reasons we hypothesize that:

*H7: Belief in EV technology has a positive effect on EV adoption likelihood*
Social reinforcement

The people around you can have a profound effect on your behavior as well as purchase intentions. Social influence in this case is when an individual’s behavior is influenced by others as a result of having used a technology. Eppstein et al. (2011) argues that social influence on behavior is an influential factor that affects choice. Buying decisions are affected by social externalities, such as peer pressure, social influences and social norms (Daziano and Chiew, 2012). A study looking at consumer purchasing behavior for hybrid vehicles found that the neighbor effect was in play (Mau et al., 2008). The same results are found by Axsen and Kurani (2011), as they report interpersonal influence to be a big influential factor in a car buyers assessment of green vehicle technology. It seems to be the case that when you have many EV drivers in your neighborhood or social circle, you are more likely to consider purchasing an EV yourself, thus, we hypothesize that:

H8: Social reinforcement has a positive effect on EV adoption likelihood

Identity

Identity theory argues that self-identity is a primary motivator of a person’s behavior (Stryker & Burke, 2000). The expectations and meanings that come with categorization of the self as an occupant of a role, form a set of standards that guide a person’s behavior. The study of Arnocky et al. (2007), argues that a consumer’s self-identity is for this reason an independent predictor of consumption behaviors. Through behavior actions, an individual will try to maintain consistency with the identity standard. Arnocky et al. (2007) also claims that previous findings show that self-construal plays a vital role in behavior prediction that is related to the environment. This social identity aspect is also identified by Graham-Rowe et al. (2012). Griskevicius et. al (2012) claims that desire for eco-friendly products is increased by identity enhancement motivations. For the aforementioned reasons we hypothesize that:

H9: Identity has a positive effect on EV adoption likelihood

Negative perception

Graham-Rowe et al. (2012) claims that drivers of EVs felt that EVs were substandard to ICE cars. They stated that the car felt underpowered. Achtnicht, (2012) found that consumers preferred more horsepower when making purchase decisions. A study on hybrid cars found comfort to be one of the most important factors to influence consumer adoption (Ozaki and Sevastyanova, 2011).
According to the study by Egbue & Long (2012), one of the most important reasons for EVs low competitiveness and demand is their high cost. It would be interesting to find out how the Dutch consumer is currently perceiving EVs and if this perception influences EV adoption. We hypothesize that:

\textit{H10: A negative perception has a negative effect on EV adoption likelihood}
3. Conceptual model

Figure 2: Conceptual Model with hypothesized relations between predictive variables and the dependent variable
In order to determine the key factors driving adoption, we are mostly interested in the extent of the hypothesized influence on EV adoption for each hypothesis. The conceptual model consisting of all hypotheses is presented with green color when there is a positive relationship and red color when there is a negative relationship (Figure 2). As can be seen, price, range anxiety and negative perception have a negative relationship with EV adoption.
4. Methodology

Procedure

For the collection of data, an extensive survey was sent out to a wide audience. It was decided to only include participants living in the Netherlands. This facilitates deriving meaningful conclusions from the data. The intention was to find an optimal sample of the population with a variety of ages and background. The convenience sampling method, in which participants are chosen by their accessibility (Bryman, 2011), was used to recruit survey respondents. In particular, a personal approach was chosen by sending an email to acquaintances with the request to fill out and spread the survey. The survey was conducted in English. In order to make sure participants would not lose focus, it was kept concise with a consistent layout. The additional explanation information in the survey towards participants was purposely kept very basic, as this would keep the chances of negatively or positively biasing the audience to a minimum. A pilot test with subsequent interviews was conducted in order to improve the survey. Feedback was received which resulted in shortening the survey as well as altering the phrasing of certain questions.

Participants

The survey has been successfully completed by 173 participants. The goal was to reach more than 100 participants. The sample consists of 121 men (69.9%) and 52 women (30.1%) (See Figure 3). The average participant age was 45.8. When it comes to age the sample is representative of the overall population, as a wide variety of ages has been documented (as shown in Figure 4). It has to be stated that the sample is highly educated, as 81.5% has finished at least a Bachelor’s degree or higher (Figure 5).

Figure 3: Gender sample statistics
Figure 4: Education sample statistics

Figure 5: Age sample statistics
Measures

In order to measure all independent variables and the dependent variable, 25 questions are asked. See Appendix I for the complete survey. All questions and variables will be described below. The scale used for independent variables is the 7-point likert scale, as using a scale with 7 points is found to be superior as opposed to less points (Preston et. al, 2000). Some independent variables will be derived from more than one question. In this case a composite variable is made combining the results of all relevant questions into one variable. The dependent variable is EV adoption likelihood. The independent variables, also called predictor variables, are: sustainability, price, fossil-fuel critical, charging station accessibility, range anxiety, belief in EV technology, experience, social reinforcement, identity and negative perception. Next, they will be discussed in more detail.

Composite independent variables
The independent variables that are conducted from more than one question are range anxiety, negative perception, charging station accessibility and sustainability. In the following tables one can find the questions that are used. These questions are phrased in the form of statements where participants are asked to share their agreement ranging from “Strongly disagree” to “Strongly agree”.

| Range Anxiety | 1. When driving a fossil-fuel car, I worry about being stranded with an empty tank |
|               | 2. When driving an EV, I would worry about being stranded with a depleted battery |
|               | 3. The fact that the car battery can be depleted, is a reason for me to stay away from EVs |
|               | 4. When driving a fossil-fuel car, I load the tank when it is: |
|               | - Empty |
|               | - Near empty |
|               | - A quarter full |
|               | - Half full |
|               | - Three-quarters full |

It is understandable that participants without experience claim they have high range anxiety if they would drive an EV. Some do not know exactly how the battery works and will automatically respond with a self-estimated claim. We have tried to make the findings less subjective by including questions that are more objectively measurable. For example, if someone already loads the tank of a
fossil-fuel car when it’s still half full it shows high range anxiety. The total average of the four questions were combined to measure this variable.

| Charging station accessibility | 1. I have the possibility/room to install a charging station at home |
|                              | 2. I have the possibility to charge my car at work |
|                              | 3. There are enough charging stations in my neighborhood |
|                              | 4. The unavailability of charging stations is a reason for me to stay away from EVs |

Charging station accessibility is measured by asking these four questions. Through these four questions we do not just get a value for this independent variable, we also find valuable insights into why they score high or low. The last question was reverse coded due to its negative phrasing. One problem we run into when using this method is that the group of questions is subject to low internal consistency. This is due to the questions being designed to complement each other instead of asking the same thing with a slight variation three times in a row. We believe that through this method the average score is representative for the actual overall value of the tested attribute. More on this can be found in the Limitations chapter.

| Sustainability | 1. Being environmentally friendly is an important factor for me when considering an EV |
|               | 2. When I’m at home, I make sure I turn off the lights in other rooms in order to be environmentally friendly |
|               | 3. When I’m at home, I make sure I turn off the lights in other rooms in order to save money |
|               | 4. Convenience is the most important aspect when it comes to determining charging time |
|               | 5. Charging environmentally friendly is the most important aspect when it comes to determining charging time |

Sustainability is a composite variable computed from the aforementioned five questions that measure how green participants are. When participants answer that they are turning the lights off to save money or that convenience is the most important factor in determining charging time, it is
the opposite of sustainable. Therefore these questions were reverse coded after obtaining the results.

<table>
<thead>
<tr>
<th>Negative Perception</th>
<th>1. EVs are less powerful than fossil-fuel cars</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. EVs are more expensive than fossil-fuel cars</td>
</tr>
<tr>
<td></td>
<td>3. EVs are less comfortable to drive than fossil-fuel cars</td>
</tr>
</tbody>
</table>

The last composite variable is negative perception. It is composed of negatively phrased statements, however it does not require reverse coding as all three questions are negatively phrased.

Single question independent variables
The other seven independent variables are all derived from one question. They are: fossil-fuel critical, identity, price, belief in EV technology, experience and social reinforcement.

<table>
<thead>
<tr>
<th>Fossil-fuel critical</th>
<th>1. The fact that fossil fuels are imported and therefore bring uncertainty (oil crisis) is a reason to consider driving an EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identity</td>
<td>2. Driving an EV is an expression of self (attitudes and values)</td>
</tr>
<tr>
<td>Price</td>
<td>3. Price is an important factor for me when considering an EV</td>
</tr>
<tr>
<td>Belief in EV technology</td>
<td>4. EVs will be the future</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>Experience</td>
<td>5. I have previous experience with EVs</td>
</tr>
<tr>
<td>Social reinforcement</td>
<td>The percentage of people in my social circle driving an EV compared to a fossil-fuel car is</td>
</tr>
<tr>
<td></td>
<td>6. _____ % Please indicate the percentage (%)</td>
</tr>
</tbody>
</table>

Using a 7-point likert scale does not always give enough information. Therefore it was decided to step away from survey consistency in order to give participants more room for precise answering methods. If “Social reinforcement” was measured on a likert scale, the statement would have been phrased as: “Many people in my social circle drive an EV as opposed to a fossil-fuel car”. Answering “1” would tell us that not many people in a participant’s social circle drive an EV. However this would leave us with little actual information. By using a slider designating a number from 0-100% it becomes more objective and it is easier to compare participants.

**Dependent variable**

<table>
<thead>
<tr>
<th>EV Purchase Likelihood</th>
<th>What is the probability (%) that you will buy an EV at some point in your life?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. _____ % Please indicate the percentage (%)</td>
</tr>
</tbody>
</table>
Similarly to "Social reinforcement", the dependent variable was measured by asking participants to use a slider designating a number from 0-100%. This was decided after reviewing the literature on the use of scales determining buying behavior. According to Wright and MacRae (2007), purchase intention scales are empirically unbiased. The accuracy of prediction models goes up when intent of purchase is added (Hsiao et. al, 2002).

Control variables

In a study conducted by Egbue and Long (2012), differences were found when looking at the interest in EVs and knowledge concerning sustainability of participants from different age groups. Participants older than 25 scored higher. It can be expected that education might influence knowledge about EVs as well. Therefore three control variables are recognized in this study: age, gender and education.

Hierarchical Multiple Regression Model

To find out which factors influence EV adoption a variant on the multiple linear regression technique is used. Multiple linear regressions are used to determine whether one continuous dependent variable can be predicted from a set of independent variables. In this study, a hierarchical multiple regression is performed to test the effects of certain independent variables independent of the influence of variables such as age, education and gender. This is done by entering variables in several stages. In stage 1 the control variables will be added. In stage 2 the independent variables will be added.

By entering age, gender and education in stage 1, these variables do not explain away associations between the dependent variable Adoption likelihood and any independent variables. Through this model it will be possible to find how much of the variance can be explained by each variable. The formula used for the hierarchical multiple regression is taken from the study of Malhotra & Birks (2000);

\[ Y_{EV\ Adoption\ Likelihood} = \beta_0 + \beta_1X_{i1} + \beta_2X_{i2} + \ldots + \beta_kX_{ik} + \epsilon \]

Where:
This multiple hierarchical regression was performed through SPSS. In block 1 the control variables age, gender and education were added. In block 2 all predictive variables were added.

Procedure
In order to make sure the results are based on accurate data, three outlier analyses were performed. Due to the method of data collection, it is a possibility that participants interpreted questions incorrectly and filled out an answer that cannot possibly be correct. When data is collected through surveys, typos are always a possibility. Outlier analyses can prove to be a valuable tool. They can point us towards problems with analysis or measurement, such as incorrect coding, or provide us with very important information that leads to new findings. Therefore, the nature of any perceived outliers always needs to be looked at. For this analysis, it was decided that outliers are only removed if they are incorrect data or if there are very specific reasons for removing them. Three outlier analyses were conducted through calculating Cook's distance, Mahalanobis distance (P=0.005) and the centered leverage value (Stevens, 1984). According to Mahalanobis and centered leverage value methods the data contains five outliers, however according to Cook's distance there are seven. These outliers should not just be dropped because they are outliers, as they might be legitimate observations. For most of these cases, it was not possible to determine whether the responses were erroneous, therefore it was decided to delete no more than two respondents. These two respondents were the only ones that were designated as an outlier by all three outlier analyses. Furthermore, an explanation was found as to why they were so different. One respondent scored high on sustainability, was fossil-fuel critical and planned to buy an EV in near future. It is expected that this respondent would also have a high belief in EV technology as a technology for the future. This turned out not to be the case, as he was a believer in hydrogen fuel cell cars. The other outlier that was removed scored extremely high on all outlier analyses as he was very positive about EVs yet had a low adoption rate of 15%. He filled out the exact same answer for the “Social reinforcement” question as well as the “Adoption rate” question. If these questions were Likert-scale this would not have been suspicious, however these questions
were both answered by using a slider designating a number from 0-100. The other outliers are believed to be simply due to random variation and are therefore not removed. This leaves a total of 171 respondents.

When running a hierarchical multiple regression the goal is to generalize the sample model to the entire population. In order for this to work, several assumptions of the regression model need to be met. If these assumptions are violated it puts a halt to the generalizing conclusions to the target population due to the results possibly being biased or misleading. The assumption for variable types is that our dependent must be continuous, while the independent variables can be continuous or dichotomous. There is an independence assumption that all values of the outcome should come from a different person of the sample. These assumptions are all met. In order to review more complicated assumptions, such as the linearity of the model, homoscedasticity, multicollinearity and normally-distributed errors, partial regression plots of the dependent variable on the Y-axis vs. the independent variable on the X-axis were created. Moreover, a scatter plot of the regression standardized predicted value and regression standardized residual was created for this purpose. See Appendix II for all plots. In the following, we will discuss the validation of these assumptions in more detail.

The relationship we model is supposed to be linear. When looking at the partial regression plots for each independent variable it is reviewed if the points are scattered and do not form a pattern. All plots show that the dots are scattered around without clear patterns. Therefore there is no reason to doubt the linearity assumption, as the dots would in this case not be scattered around but show certain patterns.

The requirement for homoscedasticity is that the variation for the predicted values is constant. The scatterplot of the regression standardized predicted value and regression standardized residual is reviewed. Around the center, the dots are scattered which indicates that the errors are normally distributed. However a pattern is observed near the top right of the scatterplot. This pattern could indicate that the residuals are not normally distributed or the residual is correlated with the independent variables. Another possibility is that the variance of the residuals are not constant. The majority of the scatterplot shows a reasonable spread, yet due to the aforementioned pattern heteroscedasticity cannot be entirely confirmed.

Through SPSS we can check for multicollinearity using variance inflation factors (VIF) and tolerance values. The VIF indicates whether a predictor has a strong linear relationship with other predictors. In order to not run into problems with multicollinearity, a VIF lower than 10 is needed and the
average VIF should not be substantially greater than 1 (Myers, 1990). Furthermore, the tolerances should not be smaller than 0.1, yet the study of Menard (1995), argues that 0.2 is a good cut-off point. The tolerance in this study stays well above 0.2, furthermore the VIFs are all lower than 10 (See Table 4). The highest VIF is 1.473 which is well below 10. The average VIF is slightly above 1, however when studying the correlation table (See Table 5), the Pearson correlation between independent variables is generally low. Therefore the independent variables do not have a strong linear relationship with each other.

When looking at normality it is checked to see if the errors are normally distributed. The histogram shows a relative normal distribution (See Appendix II) When observing the normal P-P plot (See Appendix II) it shows that the dots are generally following the straight line. Therefore it is assumed that the normality assumption is met.
5. Results

The 171 participants of this study chose an average percent chance of EV adoption of 70.5% (see Table 1) with a standard deviation of 28. One could argue that this is a very high standard deviation, however this is to be expected, as there are groups of participants claiming no intent to buy an EV at all and there are groups that are completely sure they will buy an EV. The lowest scored independent variable was “Experience” with an average value of 3.1. The highest scoring independent value was “Belief in EV technology” with an average value of 5.9 (see Table 1).

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AdoptionLikelihood</td>
<td>70.5205</td>
<td>28.10827</td>
</tr>
<tr>
<td>Age</td>
<td>45.61</td>
<td>16.821</td>
</tr>
<tr>
<td>Gender</td>
<td>1.30</td>
<td>0.461</td>
</tr>
<tr>
<td>Education</td>
<td>3.29</td>
<td>0.780</td>
</tr>
<tr>
<td>FossilFuelCritical</td>
<td>4.44</td>
<td>1.660</td>
</tr>
<tr>
<td>Identity</td>
<td>4.39</td>
<td>1.588</td>
</tr>
<tr>
<td>Price</td>
<td>5.70</td>
<td>1.112</td>
</tr>
<tr>
<td>BeliefInEVTechnology</td>
<td>5.94</td>
<td>1.192</td>
</tr>
<tr>
<td>Experience</td>
<td>3.08</td>
<td>1.951</td>
</tr>
<tr>
<td>SocialReinforcement</td>
<td>8.8772</td>
<td>9.98894</td>
</tr>
<tr>
<td>PriceRatio</td>
<td>3.65</td>
<td>1.549</td>
</tr>
<tr>
<td>Sustainability</td>
<td>4.3544</td>
<td>0.69114</td>
</tr>
<tr>
<td>RangeAnxiety</td>
<td>3.4985</td>
<td>0.93875</td>
</tr>
<tr>
<td>ChargingStationAccessibility</td>
<td>3.9693</td>
<td>1.19994</td>
</tr>
<tr>
<td>Perception</td>
<td>3.8577</td>
<td>0.97947</td>
</tr>
</tbody>
</table>

Table 1: Sample statistics

The model summary (See Table 2) shows that when only including the control variables, the R square change equals 0.119 meaning that the model can explain for 11.9% of the variance. The model is significant. When adding in the prediction variables the final model increases its prediction capabilities with 29% to a total of 41%. This model is statistically significant as well. Model 2 has a Durbin-Watson value of 1.014. This value should be between 1 and 4. If it is then that means that residuals are not highly correlated to one another. Preferably this value should be near 2. Due to our relatively low value there might be positive autocorrelation. However the study by Field (2009) argues that only values below 1 or above 3 are a reason for concern. The ANOVA table
(See Table 3) confirms that the model as a whole is a statistically significant predictor of EV adoption likelihood.

### Model Summary

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std Error of the Estimate</th>
<th>Change Statistics</th>
<th>Sig F Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R Square Change</td>
<td>F Change</td>
</tr>
<tr>
<td>1</td>
<td>.346</td>
<td>.119</td>
<td>.103</td>
<td>26.61670</td>
<td>.119</td>
<td>7.529</td>
</tr>
<tr>
<td>2</td>
<td>.639</td>
<td>.429</td>
<td>.360</td>
<td>22.48306</td>
<td>.290</td>
<td>7.095</td>
</tr>
</tbody>
</table>

Table 2: Regression model summary

### ANOVA

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>16001.764</td>
<td>3</td>
<td>5333.921</td>
<td>7.529</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>118310.915</td>
<td>167</td>
<td>708.449</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>134312.678</td>
<td>170</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Regression</td>
<td>54915.754</td>
<td>13</td>
<td>4224.289</td>
<td>8.353</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>79396.925</td>
<td>157</td>
<td>505.713</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>134312.678</td>
<td>170</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: ANOVA table

To find out how much each variable contributes to the model, the coefficients table is used (See Table 4). In the final model, the control variables age and education appear to have a significant effect on EV adoption. However, we have already controlled for them in model 1.
<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta</td>
<td>Sig.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tolerance</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Regression coefficients for EV Adoption and Collinearity Statistics
H1: Fossil-fuel critique has a positive effect on EV adoption likelihood

Fossil-fuel critique shows to have a very marginal positive effect on EV adoption. It is not a significant effect and therefore the hypothesis is rejected ($\beta = 0.011$, $p = 0.866$)(See Table 4).

H2: Identity has a positive effect on EV adoption likelihood

Even though there was a group who agreed that driving an EV is an expression of self, it did not turn out to be a good predictor of EV adoption. Identity is not a statistically significant unique contributor in the model ($\beta = -0.003$, $p = 0.963$). However, identity is a statistically significant positive correlate with EV adoption.

Price has a negative effect on EV adoption likelihood

Price did have a negative effect on the adoption of EVs. Participants who claimed that price was an important factor for them when considering an EV were less likely to buy an EV. However, price did not reach significance in the hierarchical model ($\beta = -0.012$, $p = 0.857$). The hypothesis is rejected. Price did reach significance as a negative correlate to the dependent variable.

Belief in EV technology has a positive effect on EV adoption likelihood

Belief in EV as a technology is a statistically significant unique predictor ($\beta = 0.191$, $p < 0.05$) for the dependent variable. Therefore the hypothesis is accepted. This means that people who are positive about EV as a technology and its future are more likely to buy an EV for themselves.

Experience has a positive effect on EV adoption likelihood

Experience failed to reach significance within the hierarchic model thereby the hypothesis has to be rejected ($\beta = 0.075$, $p = 0.286$). Experience also failed to reach significance as a correlate.

Social reinforcement has a positive effect on EV adoption likelihood

The positive effects of EV drivers in your social circle were not strong enough to reach significance ($\beta = 0.061$, $p = 0.401$). It seems like people will buy the car type they want regardless of their surroundings. The hypothesis is rejected.

Sustainability has a positive effect on EV adoption likelihood

Sustainability definitely has a very strong positive correlation with EV adoption. Sustainability has a positive correlation of 0.277 with a $p <0.001$ significance level. However, when operating in the
hierarchical regression, Sustainability did not reach significance ($\beta = 0.122$, $p = 0.09$). As a result, the hypothesis is rejected.

**Range anxiety has a negative effect on EV adoption likelihood**

Range anxiety shows not only a very strong significant negative correlation with EV adoption likelihood, it also reaches statistical significance in the hierarchical regression ($\beta = -0.227$, $p <0.05$). Therefore, it is confirmed that range anxiety has a negative effect on EV adoption likelihood. The hypothesis is accepted.

**Charging station accessibility has a positive effect on EV adoption likelihood**

Charging station accessibility shows the greatest Beta coefficient of all predictive variables. It is also statistically significant ($\beta = 0.255$, $p <0.05$). It is plausible that people who have easy access to charging stations are more likely to buy an EV. The hypothesis is accepted.

**A negative perception has a negative effect on EV adoption likelihood**

While it did have a negative effect as a correlate and reached significance there, it did not reach statistical significance as a unique predictor variable in the hierarchical regression model ($\beta = -0.026$, $p = 0.717$).

<table>
<thead>
<tr>
<th>Correlations</th>
<th>Pearson Correlation with DV</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption likelihood</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>-0.156</td>
<td>0.021</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.114</td>
<td>0.069</td>
</tr>
<tr>
<td>Education</td>
<td>0.273</td>
<td>0.000</td>
</tr>
<tr>
<td>Fossil-fuel Critical</td>
<td>0.124</td>
<td>0.054</td>
</tr>
<tr>
<td>Identity</td>
<td>0.183</td>
<td>0.008</td>
</tr>
<tr>
<td>Price</td>
<td>-0.136</td>
<td>0.038</td>
</tr>
<tr>
<td>Belief in EV technology</td>
<td>0.278</td>
<td>0.000</td>
</tr>
<tr>
<td>Experience</td>
<td>0.122</td>
<td>0.056</td>
</tr>
<tr>
<td>Social reinforcement</td>
<td>0.113</td>
<td>0.070</td>
</tr>
<tr>
<td>Sustainability</td>
<td>0.277</td>
<td>0.000</td>
</tr>
<tr>
<td>Range anxiety</td>
<td>-0.336</td>
<td>0.000</td>
</tr>
</tbody>
</table>
The model contains three variables reaching significance as unique predictor variables of the dependent variable. These variables are "Charging station accessibility", "Range anxiety" and "Belief in EV technology", with "Charging station accessibility" being the key factor (See Table 4). The hypotheses for these three variables has been accepted, all others are rejected. Even though many variables showed a positive or negative significant correlation with the dependent variable, that does not automatically mean that they will also be significant unique predictors in the hierarchical model. A variable that came close but did just miss significance is "Sustainability".

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation Coefficient</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charging station accessibility</td>
<td>0.357</td>
<td>0.000</td>
</tr>
<tr>
<td>Negative perception</td>
<td>-0.248</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 5: Correlations with Adoption Likelihood table
6. Discussion

Theoretical implications
In this section we will present the findings in relation to the research question: “What factors influence the rate of EV adoption in the Netherlands?”. The findings show that charging station accessibility is the most important factor, closely followed by range anxiety. Belief in EV technology also has an effect. We will show the findings for each hypothesis and its theoretical implications will be discussed. The hypotheses will be repeated as well as whether they are accepted or rejected and why. If a hypothesis is not supported, an alternative explanation will be provided.

H1: Price has a negative effect on EV adoption likelihood
We hypothesized that the generally higher price of EVs influences EV adoption negatively. In the hierarchical regression model, while the relationship was negative, it did not turn out as a significant predictor for EV adoption likelihood. The hypothesis is therefore rejected. This is in conflict with most literature, as a study by Lane and Potter (2007) found that upfront purchase price is a deciding factor and Hidrue et al. (2011) found similar results. However, there are researchers who have found that financial incentives are not as influential as we might think. Diamond (2009), found that financial incentives only have a weak positive influence on EV adoption. Sierzchula et al. (2014) claims that a reason for this is that other factors such as sustainability simply have a stronger influence. They also suggest that the interaction with other factors could be an explanation. The notion that financial incentives is not a strong predictor of EV adoption finds some basis in other literature as well. Studies on hybrid vehicles showed that drivers are often neither able nor interested in calculating the economic efficiency of vehicles (Feiler and Soll, 2010; Gardner and Abraham, 2008; Turrentine and Kurani, 2007).

H2: Charging station accessibility has a positive effect on EV adoption likelihood
Charging stations are vital for an EV user, as you cannot charge your battery without one. Not everyone has ample space for a home charging station and in some cities the public charging stations always seem occupied. There might be a lot of people who would like to buy an EV, but simply refrain from doing so because of the inaccessibility of charging stations. We hypothesized that charging station accessibility has a positive effect on EV adoption likelihood. The findings show that this is the key factor for EV adoption, thereby supporting the hypothesis. The literature supports the positive influence charging stations have on EV adoption (Sierzchula et al., 2014).
study by Silvester et al. (2013) calls charging stations crucial, while Dagsvik et al. (2002) claims they are a necessity in order to compete with ICEs.

**H3: Sustainability has a positive effect on EV adoption likelihood**

One of the main reasons to choose an EV over an ICE is the fact that EVs produce zero emissions. Chen et al. (2016) reports that the environmental attitudes of consumers have a strong influence on the intent to buy alternative fuel vehicles. Therefore we hypothesized that sustainability has a positive effect on EV adoption likelihood. The data shows that sustainability is a positive correlate for EV adoption. However, the results of the hierarchical regression show it is not a significant predictor of EV adoption. Therefore, the hypothesis is not supported. This is inconsistent with most of the literature. There is some data that supports the notion that while consumers have positive attitudes towards sustainability, it does not translate into corresponding behavior (Gatersleben et al., 2002). The studied relationship in this study was between environmental attitudes and energy consumption. The researchers claimed that there was only a weak relationship. A possible explanation is that participants claim to be more environmentally minded than they actually are.

**H4: Fossil-fuel critical has a positive effect on EV adoption likelihood**

We hypothesized that consumers who are critical of fossil-fuels and its unstable market would be more likely to buy an EV. The results show that fossil-fuel critical as a factor is not a significant predictor of EV adoption, thus the hypothesis is rejected. This is likely due to the fact that oil prices have been very low throughout the last 3 years. Ever since the crash in 2014 the oil price of crude oil has stayed below 60 dollars which does not give a boost to switching to EV (Nasdaq, 2017). ICE drivers are very happy with the low oil price and find themselves paying considerably less filling up their tank than a few years ago.

Another reason why people might be less critical of fossil-fuel is that the current crash is a supply driven crash. The oil producing countries are reluctant to slow down production. This has caused a big decrease in consumer prices of oil which subsequently might slow the adoption of EVs. This theory is confirmed by Gallagher and Muehlegger (2010), as they argue that adoption is influenced by fuel prices. It’s a possibility that participants are swayed by the low fuel prices, do not expect to see the fuel prices rise very soon and are therefore less critical of fossil-fuel’s downsides.
H5: Range anxiety has a negative effect on EV adoption likelihood

Electric vehicles use a battery that depletes slowly when driving. Running out of battery while in the middle of a trip is a common fear among EV users. Therefore we hypothesized that the amount of range anxiety consumers suffer from has a negative effect on EV adoption. The results show that range anxiety is the second most important factor influencing EV adoption, thus supporting the hypothesis. These findings are consistent with the literature. Lieven et al. (2011), Cheron and Zins (1997), Hidrue et al. (2011), Franke & Krems (2013), Bühler et al. (2014), Jensen et al. (2013) and finally Tate et al. (2008) all state that range is important. The effect measured in these studies was on hybrids, therefore the effect on all-battery vehicles in our study is likely even stronger.

H6: Experience has a positive effect on EV adoption likelihood

We hypothesized that many of the downsides of EVs could be mitigated by getting to know the technology. The results show that while it was a positive effect, it was not significant in the model thereby not supporting the hypothesis. This is consistent with the literature as they showed mixed results as well. Skippon and Garwood (2011) and Graham-Rowe et al. (2012) reported both good and bad effects, one of which was that participants were sceptic about whether or not EVs are suitable for daily use. Bühler et al. (2014) also found that experience can enhance both positive and negative effects.

H7: Belief in EV technology has a positive effect on EV adoption likelihood

When consumers believe in EV as a technology and are positive about its future, they are probably more likely to buy one. Therefore we hypothesized that belief in EV technology influences EV adoption rate. The effects were not as strong as for key factors such as range anxiety and charging station accessibility, but were significant thereby accepting the hypothesis. There appears to be some basis for this in the literature as people generally are excited to learn new technologies (Jabeen et al. 2012). Egbue & Long (2012) showed that participants referred to EVs as the future of transportation. Participants called it “the way of the future” and “future of travel”. These were found to be positive associations.

H8: Social reinforcement has a positive effect on EV adoption likelihood

Social influence on behavior is an influential factor that affects choice (Eppstein et al., 2011). We hypothesized that purchasing behavior of EVs would be affected by interpersonal influence as well.
That is why participants were asked how many EV drivers there were in their social circle. The data show that even though there is a positive effect, it is not significant. A possible explanation for this is that in Dutch society, social externalities such as peer pressure might not be as prevalent. Another explanation is that these effects would be much stronger when the EV group is the majority and the ICE group the minority.

**H9: Identity has a positive effect on EV adoption likelihood**

Identity theory argues that self-identity is a primary motivator of a person’s behavior (Stryker & Burke, 2000). We hypothesized that if consumers saw driving an EV as an opportunity to express their values and as an expression of self, it would dictate their consumption behavior. The results show that it is not a major predictor of EV adoption in the Netherlands, thereby not supporting the hypothesis. This result is backed by Barbarossa et al. (2015) who found a similar result on consumers in Belgium. They reported that if consumers had high green self-identity, they were more considerate about environmental consequences. They also found that it influenced their attitude towards adoption of EVs indirectly through these environmental consequences. However, the most important outcome, which is consistent with our findings, is that the direct effect of green self-identity on Belgium consumer intention to adopt EVs was not significant.

**H10: A negative perception has a negative effect on EV adoption likelihood**

Graham-Rowe et al. (2012) claims that drivers of EVs felt that EVs were substandard to ICE cars. We hypothesized that if consumers indeed had negative perceptions about EVs, they would influence EV adoption. While a negative correlation was found, there was no significance. Therefore, the hypothesis was not supported. Most of the participants in this research did not have these negative perceptions. Many were highly educated, possibly not falling for these perceptions or already having accounted for them, thus not letting these perceptions influence their purchasing behavior. Another explanation is that the EV market in 2017 is becoming a lot more sophisticated and information on EVs is readily available for everyone.
Societal implications
In the “Green Deal Elektrisch Vervoer 2016-2020”, the Netherlands has declared the ambition to set the international standard when it comes to electric driving. For this deal, a wide variety of parties came together to set goals and share ambitions. This party consists of EV manufacturers, policymakers, grid operators, public transit companies and other municipalities. Due to the close cooperation between these parties, participants believe that the Netherlands can stay ahead of other countries when it comes to knowledge about EV infrastructure and possibly make it an export product of our country (Living lab, 2017). To set the international standard, participants of the Green Deal cooperate to collectively contribute to the “Living Lab Smart Charging”. This organization has many ambitious goals. They hope to see one million EVs in 2025 and all of the Netherlands driving EVs in 2030 (Rijksoverheid, 2014).

The findings of this study can aid in achieving these goals and point out where the focus needs to be in order to accommodate for such a radical change from ICE to EV. As reported previously, range anxiety was found to be one of the key determinants of EV adoption. As technology improves over time, batteries will increase in capacity thereby increasing the range of EVs. This will in itself lower range anxiety. Another way to reduce range anxiety is educating people. The prevalence of range anxiety shows that consumers are uninformed (Franke et al., 2012). They claim that when consumers gain knowledge, their range anxiety diminishes as they learn how long their battery lasts and when they need to charge their car. Another way to partly remove range anxiety is installing ample charging infrastructure. Ample public charging stations and quick chargers at gas stations would help immensely. This brings us to the most important factor to help grow EV adoption in the Netherlands: charging station accessibility. The state of charging infrastructure in the Netherlands can be found below (See Table 6):

<table>
<thead>
<tr>
<th>Type of charging station</th>
<th>Number in the Netherlands (per October 2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home charging station</td>
<td>60.000</td>
</tr>
<tr>
<td>Work charging station</td>
<td>12.400</td>
</tr>
<tr>
<td>Public charging station</td>
<td>14.050</td>
</tr>
<tr>
<td>Corridor charging station (gas stations)</td>
<td>579</td>
</tr>
</tbody>
</table>
Public charging stations are critical for long journeys and for households without facilities for home charging. However, home charging is by far the most prevalent way of charging as it is estimated to account for nearly 80% of total charging in the beginning phases of EV adoption (McKinsey, 2014). Norway, the country who is an EV frontrunner with Electric Vehicles representing 1.75% of the total number of vehicles on the road, nearly 95% of (H)EV owners have access to a private home charging station. Public charging stations will be a necessity even in the long-term, as approximately 65% of households do not have a private parking space. On the long-term, public charging will remain necessary as in Europe, around 65% of the households do not have a private parking space (Sia Partners, 2016).

A recent survey conducted in the city Utrecht in the Netherlands showed that only 18% of the EV users believe that there are enough charging stations in cities. Furthermore, less than 25% has a charging station near their residence. When connecting the findings of the survey to our key finding, the importance of charging station accessibility on EV adoption, it becomes clear how necessary it is to upgrade the charging infrastructure. This might seem surprising, as the Netherlands is often praised for its charging infrastructure. The Netherlands is only behind Norway in coverage with 12.39% and 14.84% coverage respectively in 2014. This means that for every 7 EVs there was approximately 1 charging station. While this seems decent, it is not enough if the goal is mass EV adoption.

There is an important opportunity here for the Dutch government if it wants to reach the goals of the “Green Deal”, as the business case for installing charging stations is not necessarily a positive one. Commercial viability is a big challenge (McKinsey, 2014). The viability of these stations will become better if there are more EVs. Yet, there won’t be more EVs without these stations.

What else can be done to solve the problem of charging station accessibility and thereby indirectly range anxiety? The answer to this question is smart charging. Smart charging makes charging stations commercially viable. This results in more charging stations being built and a higher charging station accessibility achieved. Smart charging helps with making charging stations commercially viable through load shifting and a technique called Vehicle to Grid (V2G). We will elaborate on this shortly.
Smart charging is not directly related to EV adoption, however indirectly it does influence many of the factors that were proven to be significant correlates of EV adoption. As we already discussed it is capable of making the business case for charging stations a positive one. It also increases sustainability as well as cost-effectiveness through charging cars at moments of excess supply and a negative energy price. Furthermore, public charging stations can charge more cars at the same time thanks to Local Load Balancing. This is a smart charging project which divides the available energy between all charging cars using smart technology (Elaad, 2017), thereby increasing charging station accessibility even more.

Smart charging can help convince customers to adopt EVs as interesting opportunities for EV owners as well as charging station operators arise. An example is company Jedlix, which uses your car battery to generate financial rewards (Jedlix, 2017). It charges your battery based on supply and demand thereby relieving the grid at peak energy moments. For this balancing act they are rewarded. These rewards are then shared.

Finally, if the mass EV adoption scenario becomes reality, it will soon impose a threat for the stability of the energy grid. The energy demand by EVs is large and demand peaks occur uncoordinated (Valogianni et. al, 2013). Through Vehicle to Grid technology vehicles give energy back to the grid. If EVs are widely adopted it could be a huge help in balancing peak energy moments (McKinsey 2014). The consumer needs to be educated on these possibilities, especially the financial and practical benefits need to be shared. It will likely increase the EV adoption.
Limitations and future research directions

In this chapter we will discuss the limitations regarding choice of participants, methods that were chosen, the analysis of data and general restrictions on the scope of this research. Finally, recommendations will be made on possible future research that will validate the findings of this research or enhance the research gap.

This study is based on a survey that used convenience sampling to acquire its participants. Convenience sampling was an attractive choice considering the amount of participants needed. However, the convenience sampling method is subject to several biases. The participants might have finished the survey because they were interested in EVs, while others did not as they did not like the subject. As the participants are not chosen at random, it is unlikely that the sample is fully representative of the population of the Netherlands. We have tried to counteract this by sending the survey to a variety of age groups, yet it still undermines our ability to make generalizations. Moreover, there is a bias active in the demographics of the sample. The participants were on average highly educated, male, and lived in and around the Dutch Randstad area. This means that the research focuses on the Dutch Randstad area. It is the densest populated area and therefore contains the most potential EV users. However, the results might not be representative for the population living in more rural areas like Groningen or Friesland. It is possible that there were measurement errors due to miscomprehension, as the survey was in English, while most of the respondents were Dutch.

The literature is mixed on using purchase intention scales. Research by Young et al. (1998) claims that intentions almost always provide biased measures. Another possibility is the fact that participants might be uninformed while filling out the survey. Yet, when they decide to purchase a new car they will search for information which could possibly alter their views and influence certain hypotheses.

When designing the survey we realized that participants could act socially desirable or respond with an idealized persona bias when answering the questions. Therefore we ask several questions for attributes like sustainability. To specify: one question directly asks how important being environmentally friendly is for them, the other asks if they turn off the lights for price savings or for being green and the last question asks if they would determine charging time by convenience or environmentally friendliness. The problem with this approach is that while all questions test sustainability, due to their different angles they suffer from internal consistency as respondents answer them differently. The other composite variables: range anxiety, charging station
accessibility and perception also have this occurrence. A participant who has no home charger, no charger at work, but does have many charging stations in the neighborhood would answer the questions as opposites with strongly agree and strongly disagree and then an average charging station accessibility attribute is composed. Due to the nature of these questions there is low internal consistency to the questions as they are designed to complement each other instead of being nearly identical. We do believe that the average score is representative for the actual overall value of the tested attribute. Nevertheless, it is recommended that the study is repeated with a larger and more varied sample size as this will be able to confirm the findings, while critically evaluating the quality of the questions that test each attribute and possibly revise them.

The scope of this research is restricted to the precise set of the 10 predictor variables. As a result this study does not cover all the aspects that possibly influence EVs. If a similar method is chosen, we recommend cost-effectiveness and Total Cost of Ownership are added to the list of attributes, as we could only test so many attributes, but regret not having added cost-effectiveness and TCO ourselves.

In the section where societal implications were discussed, we stumbled upon several interesting topics that could benefit from further research. A possible topic is: how to make cities future-proof if EV adoption is enhanced. For this topic (H)EV adoption is predicted using a simulation analysis. Based on these results the total burden on the grid can be estimated and cities can be redesigned to facilitate easy access to public charging stations.
7. Conclusion

The Netherlands are making big steps towards becoming the frontrunner for EVs, as the ambitious goal of 1 million (H)EVs in 2025 is set. In order to succeed, consumers need to be willing to jump on the opportunity to buy an EV. Yet, this seems not to be the case so far, as ICE sales persistently outperform EV sales. This research can help to change the tide by answering the following question: What factors influence the rate of EV adoption in the Netherlands?

In order to determine the key factors driving EV adoption, a survey was conducted on 173 respondents living in the Netherlands. Through a hierarchical multiple regression the extent of the hypothesized influence on EV adoption was determined for each of the 10 predictor variables.

The findings show three factors influencing EV adoption: charging station accessibility, range anxiety and belief in EV technology. The literature supports these factors as predictors. The other hypotheses were rejected. Factors such as sustainability, price, fossil-fuel critical, experience, social reinforcement, identity and negative perception were not significant as predictors. Alternative explanations as to why promising factors like sustainability and price were no good predictors of EV adoption were discussed. For example, it was found that while consumers may carry positive attitudes towards sustainability, it does not necessarily translate into corresponding behavior.

When presented with the facts, it is no surprise that charging station accessibility in combination with range anxiety is the most important for EV adoption. They are both vital to the primary function of a car. The primary function of a car is bringing a person from one place to another. If the battery is empty, the car will not fulfill its purpose and loses all value. EVs will therefore never be able to serve a huge chunk of the market if the quality of public charging infrastructure does not change. 65% of households have no private parking space and are therefore always dependent on public charging if they were to buy an EV. The reality is that consumers in this situation will rarely consider an EV as the uncertainty and nuisance of always having to search for public charging is too high.

The survey conducted in Utrecht once again highlighted the lack of charging station accessibility that the average consumer perceives. We suggest a two-step focus. First, a reliable basic coverage needs to be built up. This will lower range anxiety due to ample charging opportunities while on the road and it will popularize EV adoption as a whole. Secondly, when EV adoption grows, the number of charging stations needs to grow accordingly. There is an important job for grid operators and
car-manufacturers, but it is difficult to go from a beginners phase to mass adoption if the government does not actively take part. Until a solid base of EV users has been reached and the business case for charging stations has gone from negative to positive, the government needs to be pro-active.
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Appendices

Appendix I - Survey

This study is about electric vehicles. All-electric vehicles, from now on referred to as EVs, run on electricity only. They are propelled by an electric motor powered by rechargeable battery packs. EVs are better for the environment than fossil-fuel cars, as no petrol or diesel is used. To what extent do you agree/disagree with the following statements?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree (1)</th>
<th>Disagree (2)</th>
<th>Somewhat disagree (3)</th>
<th>Neither agree nor disagree (4)</th>
<th>Somewhat agree (5)</th>
<th>Agree (6)</th>
<th>Strongly agree (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Being environmentally friendly is an important factor for me when considering an EV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The fact that fossil fuels are imported and therefore bring uncertainty (oil crisis) is a reason to consider driving an EV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Driving an EV is an expression of self (attitudes and values)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. EVs are less powerful than fossil-fuel cars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. EVs are more expensive than fossil-fuel cars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. EVs are less comfortable to drive than fossil-fuel cars</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7. Price is an important factor for me when considering an EV</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>8. EVs will be the future</td>
<td></td>
<td></td>
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<tr>
<td>9. I have previous experience with EVs</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
To what extent do you agree/disagree with the following statements?

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Somewhat disagree (3)</th>
<th>Neither agree nor disagree (4)</th>
<th>Somewhat agree (5)</th>
<th>Agree (6)</th>
<th>Strongly agree (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. When I’m at home, I make sure I turn off the lights in other rooms in order to be environmentally friendly</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>11. When I’m at home, I make sure I turn off the lights in other rooms in order to save money</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>12. Convenience is the most important aspect when it comes to determining charging time</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>13. Charging environmentally friendly is the most important aspect when it comes to determining charging time</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>14. When driving a fossil-fuel car, I worry about being stranded with an empty tank</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>15. When driving an EV, I would worry about being stranded with a depleted battery</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>16. The fact that the car battery can be depleted, is a reason for me to stay away from EVs</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
To what extent do you agree/disagree with the following statements?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree (1)</th>
<th>Disagree (2)</th>
<th>Somewhat disagree (3)</th>
<th>Neither agree nor disagree (4)</th>
<th>Somewhat agree (5)</th>
<th>Agree (6)</th>
<th>Strongly agree (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17. I have the possibility/room to install a charging station at home</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. I have the possibility to charge my car at work</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>19. There are enough charging stations in my neighborhood</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. The unavailability of charging stations is a reason for me to stay away from EVs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. The government should build charging stations all over the Netherlands, even in rural areas, so that full coverage can be achieved</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

22. When driving a fossil-fuel car, I load the tank when it is:

- Empty
- Near empty
- A quarter full
- Half full
- Three-quarters full

23. The percentage of people in my social circle driving an EV compared to a fossil-fuel car is _____ % Please indicate the percentage (%).
24. For what price would you consider buying an EV over a fossil-fuel car? 70% means an EV needs to be 30% cheaper than a fossil-fuel car. 130% means you are willing to pay a premium for an EV.

- 70%
- 80%
- 90%
- 100%
- 110%
- 120%
- 130%

25. What is the probability (%) that you will buy an EV at some point in your life?

_____ % Please indicate the percentage (%).

Please indicate your:

Gender

- Male
- Female

Age:

_______________

Nationality:

_______________

Highest level of education completed:

- Elementary Education (Primary School)
- Secondary Education (High school)
- Undergraduate (Bachelor's) Degree
- Postgraduate (Masters) Degree or higher
Appendix II – Linear regression assumptions

Scatterplot

Dependent Variable: AdoptionLikelihood

Regression Standardized Residual vs. Regression Standardized Predicted Value
Partial Regression Plot
Dependent Variable: AdoptionLikelihood

Partial Regression Plot
Dependent Variable: AdoptionLikelihood
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: AdoptionLikelihood
Histogram

Dependent Variable: AdoptionLikelihood

Mean = 6.7E-16
Std. Dev. = 0.958
N = 171