The Road Ahead

A study on the factors influencing the adoption of Hybrid and Electric Vehicles in The Netherlands

**Insights from a conjoint analysis among Dutch respondents**

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A Study on the Factors Influencing the Adoption of Hybrid and Electric Vehicles in The Netherlands

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Preface

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Acknowledgements

With this thesis, I am concluding the master Business Information Management. Before starting this thesis, I had no affinity with cars other than driving my parents’ one, let alone electric vehicles. My great interest in climate change and the environment has let me to choose the topic of hybrid and electric vehicle adoption, as to be able to contribute to this issue, however minor this may be. I am convinced though that each contribution to this topic is a piece of the larger puzzle, and taken together these pieces will play a valuable role in our future.

First and foremost, I would like to thank my thesis coach Micha Kahlen for his continuous support, advice and guidance throughout the thesis trajectory, and especially for always giving me very fast, valuable and honest feedback. Secondly, I would like to thank my co-reader Mark Boons, who has provided me with great help and was always available for discussions, going far beyond of what is expected from a co-reader. Moreover, I am grateful to my Stedin company coaches Baerte de Brey and Henk Fidder for their enthusiasm, guidance and willingness to share their knowledge, and their much appreciated help in gathering survey responses. Also, I would like to thank Mr. Leon van der Spek and Mr. Jordy van Luijk, for their willingness to participate in the interviews and providing me with insights in the (H)EV market.

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June 18th 2015
Executive Summary

Purpose: As the hybrid- and full electric vehicle landscape is developing worldwide in a rapid pace, the number of hybrid electric vehicles (HEV) and full electric vehicles (EV) is expected to rise substantially in the coming years. However, it is uncertain what factors are the main drivers behind this adoption, how large the growth of (H)EV adoption will be, and what barriers need to be overcome in order to enable large-scale (H)EV adoption. Grid operators need to be able to timely anticipate on the corresponding increase in electricity demand, by adjusting the grid infrastructure or shift electricity demand to off-peak times. Moreover, governments facing decisions regarding the provision of incentives need to understand the impact and effectiveness of these incentives, and what aspects of electric driving need to be advanced to cause broad (H)EV adoption. (H)EV manufacturers will benefit from knowing the impact of various factors, thereby allowing them to focus on developing the most crucial features to enable fast adoption. For this purpose, the following research question is guiding throughout our research structure and answered: What are the main factors influencing the adoption of (Hybrid) Electric Vehicles?

Methods: Research is conducted using a survey among 307 Dutch respondents, after which a conjoint analysis is used to be able to model the adoption of hybrid and full electric vehicles in the Netherlands. This adoption likelihood is analyzed based on six factors: purchase price difference, annual cost savings, range, charging time, fast charging time and detour time. Additional interviews with two professionals from the (H)EV market – EV salesmen – are conducted to validate our answers. Utility estimation is used to identify the importance of each factor in a purchase consideration. Furthermore, a multiple regression model is applied to estimate the purchase likelihood for both hybrid electric vehicles and full electric vehicles.

Findings: It is found that for HEVs, price is the most important factor ($\beta=-.299$), followed by range ($\beta=-.231$) and annual cost savings ($\beta=.088$). Fast charging time is a significant predictor as well ($\beta=.045$), although showing a weaker and less significant relationship than the former factors. Both charging time and detour time do not show to be significant in our HEV model. For full electric vehicles, range ($\beta=0.329$) is the most important factor followed by price ($\beta=-.283$) and annual cost savings ($\beta=.087$). This difference in importance of range is likely caused by the inability to switch to a combustion engine when driving an EV, thereby increasing range anxiety. Again, fast charging time appears to have moderately significant influence on the purchase likelihood of EVs ($\beta=-.040$), and charging time as well as detour time is not significant in our EV model.

The abovementioned results are supported by our interviewees as well, who argue range and price to be the most important factors in (H)EV adoption. Furthermore, it was stated that the
current charging infrastructure is adequate and does not limit adoption, yet the need for timely development of the infrastructure is stressed to prevent this factor turning into a barrier.

Furthermore, lease drivers were found to have a higher interest in electric driving than private drivers, which is reflected in the consistently higher purchase intentions of hybrid and full electric vehicles among lease drivers.

**Implications:** Car and battery manufacturers should focus their efforts on developing batteries with a range of about 200 km, and thereafter focus on extending ranges to values similar to ICE cars, being 500 km or more. Since battery and price are inextricably bound, it is essential for (H)EV manufacturers to balance these key factors. Keeping in mind the high price of (H)EVs, tax benefits can substantially lower the price barrier of (H)EVs by mitigating the large initial investment. Thus, governments should keep financial stimuli for electric driving in place, until prices of (H)EVs are at lower levels. Moreover, battery manufacturers, grid operators as well as national governments should mainly focus on developing the fast charging infrastructure, being faster battery charging and increasing the number of charging points along major (high)ways. This will increase the mobility of (H)EV drivers, thereby leading to an increase in adoption.

**Limitations:** The emphasis of this thesis rests on six previously identified factors influencing (H)EV adoption. Therefore, the scope of this research is limited to this specific set of variables that were uncovered by previous researchers, and hence it does not, and cannot, intend to cover the full range of influencing factors. Future studies may wish to include our incorporated variables as well as variables revealed in the findings of this study, such as towing capacity, an all-encompassing variable for Total Cost of Ownership and international charging infrastructure.

**Keywords:** Annual Cost Saving, Charging, Detour time, Electricity infrastructure, Electric Vehicle, Fast charging, Fuel Price, Government, Governmental Incentives, Grid, Grid Operator, Hybrid Electric Vehicle, Purchase Price, Range, Range Anxiety
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Glossary

This paper uses the following abbreviations:

EV = (full) Electric Vehicle
HEV = Hybrid Electric Vehicle
ICE = Internal Combustion Engine
HOV = High Occupancy Vehicle
Introduction

With the global number of motor vehicles surpassing 1 billion in 2010 (Sousanis 2011) the need for alternative fuel vehicles is growing in order to be able to counter the problems caused by internal combustion engine (ICE) vehicles. Not only are countries heavily dependent on imported foreign crude oil and subject to the associated politics and price instabilities, the world’s oil reserves are rapidly depleting too. Moreover, the exhaust emissions of ICEs are harmful to the environment as well as people’s health. Therefore, since the 1960s continuous attempts have been done to produce practical and efficient (hybrid) electric vehicles, as to provide an alternative to ICE vehicles. Hybrid electric vehicles are powered by an electric motor and a gasoline engine, where the engine provides most power and the electric motor serves as an additional power supplier. On the contrary, full electric vehicles are solely powered by rechargeable batteries, and do not contain a gasoline engine (Argueta and Holms 2010).

Over the past years, the number of electric vehicles worldwide has significantly increased. Resulting from doubling EV sales figures between 2011 and 2012, the global number of electric vehicles was over 180,000 in 2012. The Electric Vehicle Initiative aims to surpass 20 million electric vehicles worldwide by 2020, consisting of (plug-in) hybrid vehicles (HEV), battery electric vehicles (EV) and fuel cell electric vehicles (FEV) (International Energy Agency 2013).

However, the market share of (H)EVs is still far below the market share of ICE’s. The amount of HEVs and EVs in The Netherlands, Norway and UK has been rising steadily over the past years to more than 40,000 vehicles per country (see Figure 1). In The Netherlands, the number of EV’s has increased to almost 44,000 by the end of 2014, which is a 53% increase compared to the year before (RVO 2015). About 84% of these vehicles are hybrid plug-in, with the remaining 16% being full electric vehicles. The Dutch government has envisioned an increase in the number of electric vehicles to 200,000 by 2020, and 1 million by 2025 (Rijksoverheid 2014).

( Hybrid) Electric vehicles have the largest market share in Norway, where the total sums up to 1.6% (Young 2015). The Netherlands are second, where the total market share of hybrid and full electric vehicles amounts to 0.6% in 2014 (RVO 2015, CBS 2015). Finally, in The UK the market share of (H)EV’s has risen to approximately 0.02% (GOV.UK 2014).

According to McKinsey, and as can be concluded from Figure 1, the adoption of electric vehicles in Europe took off in 2013 and expanded further during 2014. The adoption of EV’s is mainly driven by consumer demand, industry developments and government stimuli (McKinsey 2014). Regarding industry developments, technological advances such as more sophisticated batteries and charging infrastructure have decreased barriers in the process of adopting an (H)EV. Considering the latter force, government stimuli, national and regional governments have implemented incentives to stimulate ownership and successfully raised the number of (H)EV’s.
For example, tax exemptions or reductions were introduced in the Netherlands, Austria and Germany, whereas premiums or bonus payments were introduced in countries such as Luxembourg and the UK (ACEA 2014).

![Figure 1: Total number of (H)EVs in The Netherlands, Norway and UK (RVO 2015, Gronnbil 2015, Gov.uk 2014). Total (H)EV numbers have been rising steadily since 2012.](image)

Naturally, a rise in the number of electric vehicles increases electricity demand. However, since the electricity grid has a maximum capacity of electricity it can provide, higher demand can pose heavy burdens on the electricity infrastructure or even lead to excess electricity demand not being satisfied. As shown by Kelly et al. (2012), most charging of (H)EV’s occurs around 8pm. Charging at this time poses a substantial additional load on the infrastructure, since households generally have the highest electricity consumption at night when people are at home cooking, washing or watching television. Therefore, grid operators will either have to invest in a capacity increase of the infrastructure to be able to satisfy electricity demand, or find ways to shift (H)EV charging away from peak-hours in order to efficiently utilize the current infrastructure.

As mentioned above, the Dutch government has mainly stimulated electric driving by providing several fiscal benefits to users. EV drivers benefited of no fiscal surcharge for two years when leasing an electric vehicle. Furthermore, highly environmental friendly cars were exempted from motor vehicle tax. However, it can be expected that these benefits will change in the future. For example, as of 2014 the fiscal surcharge increased from 0% to 4% for fully electric vehicles, and to 7% for hybrid vehicles. Furthermore, it is envisioned to eliminate the exemption of vehicle tax from 2016 onwards (Ministerie van Financien 2011). See Appendix I for a full overview of the past, current and future Dutch tax policies.

With the electric vehicle landscape developing worldwide, technology progresses and government incentives are expected to vary and change in the upcoming years. In turn, these
changes will affect the amount of electric vehicles being driven, the charging behavior of electric drivers, and ultimately the electricity demand posed on the grid.

As argued in literature – and discussed in the next chapter – government incentives are not the sole or even main factor driving EV adoption. Various other elements influence adoption of (Hybrid) Electric Vehicles, such as the aforementioned technological progress leading to increasing driving range or decreased charging times of (H)EV's. Therefore, the objective of this research is to investigate the effect and importance of all factors associated with (H)EV adoption. Thus, the research question is as follows:

**What are the main factors influencing the adoption of (Hybrid) Electric Vehicles?**

And more specific:

**What is the extent of the influence of these factors on the adoption of (Hybrid) Electric Vehicles?**

Until now, several studies have been conducted regarding the effect of governmental incentives on the amount of electric vehicles being driven. These researches were mainly based on the U.S.A. (Diamond 2009, Jenn et al. 2013, Gallagher and Muehlegger 2008). However, these studies often neglected the effect of non-monetary factors on HEV adoption, or only incorporated governmental stimuli without regarding the effect of e.g. industry developments.

Subsequent studies were conducted which did include non-monetary factors influencing (H)EV adoption (Lieven et al. 2011, Hidrue et al. 2011, Bockarjova et al. 2013). Yet, these studies did not incorporate all major factors influencing (H)EV adoption. Besides, the data collection of these studies happened at least three years ago, meaning results might differ now that the (H)EV industry has further developed.

For governments worldwide it is valuable to know which factors are major drivers and/or barriers in large scale (H)EV adoption, and what the magnitude of change in intended adoption is under varying levels of these factors. Moreover, for grid operators it is of utmost importance to have a clear understanding of the driving forces behind the adoption rate of (H)EVs. This will help grid operators in anticipating on necessary infrastructure upgrades and taking timely actions. Finally, (H)EV manufacturers will benefit from knowing the impact of various factors, thereby allowing them to focus on developing the most crucial features to enable fast adoption.
Hypothesis development

(H)EVs provide several advantages, such as a higher efficiency in energy use and reduction in hydrocarbon and carbon monoxide, thereby decreasing environmental pollution. Moreover, the electricity needed to power the vehicle can easily be obtained from any electricity source. However, electric vehicles only have a limited distance which can be driven before the battery is depleted, and recharging the battery can take a substantial amount of time. Furthermore, the battery packs are heavy; thereby increasing the weight of the car, and these battery packs are considerably expensive (Argueta and Holm 2010).

So far, several studies have researched how the above mentioned advantages and disadvantages translate into drivers and barriers of (hybrid) electric vehicle adoption. Our hypotheses based on this line of research are presented below.

As displayed in Figure 1, the adoption of both hybrid as well as full electric vehicles is stimulated by several factors, being annual cost savings (which includes fuel price savings as well as government financial incentives), driving range, detour times (a proxy for charging infrastructure), normal as well as fast charging times, and finally (H)EV price.

**Governmental (financial) incentives and fuel prices**

To start with, governmental monetary incentives affect the adoption of (H)EVs. As was shown by Chandra et al. (2008), Gallagher and Muehlegger (2010), Jenn et al. (2013), and Bockarjova et al. (2013), financial incentives imposed by the government positively influence (H)EV sales and adoption intention. Consumers are stimulated to buy an (H)EV due to the presence of monetary benefits when purchasing such a vehicle, as these benefits are not received when buying an Internal Combustion Engine (ICE) car. As the price of an (H)EV is still considerably higher than the price of a similar ICE car, these financial incentives decrease the adoption barrier of (H)EVs.

Non-monetary governmental incentives such as access to High Occupancy Vehicles (HOV) lanes are positively correlated to HEV sales, as concluded by Gallagher and Muehlegger (2010). Non-monetary benefits provide extra comfort to drivers, thereby increasing the attractiveness of (H)EVs. However, since these incentives are currently not present in the Netherlands nor are envisioned to be implemented (RVO 2015), this factor is omitted from our study.

Furthermore, adoption motivation for (H)EVs is influenced by the fuel price. As was shown by e.g. Year of the Hybrid (2004), McManus and Berman (2005), Diamond (2009) and Gallagher and Muehlegger (2010), rising gasoline or diesel price leads to an increase in (H)EV purchases, since the driver will save considerable amounts of money on gasoline. As the cost of electricity is considerably lower than fuel costs, an (H)EV is the more economic option when only regarding
fuel costs. If these fuel costs increase further, the incentive to drive an (H)EV becomes even larger. Therefore, combining these two factors into the comprehending factor of annual cost savings, the following hypothesis is derived:

**H1: Annual cost savings have a positive effect on (H)EV purchase likelihood**

After reviewing the existing literature, it seems obvious that financial incentives positively influence (H)EV adoption. Therefore this research is mainly focused on the extent of this positive effect. As mentioned before, some studies (e.g. Diamond 2009) found that government financial incentives only have a weak positive influence on (H)EV adoption. As suggested by Sierzchula et al. (2014), this might be due to other factors having a stronger influence on (H)EV adoption, or the presence of factors interacting with the financial incentive variable.

**Driving range**

Driving range is another factor influencing (H)EV adoption. As indicated by e.g. Lieven et al. (2011) and Cheron and Zins (1997), the limited driving range of (H)EV’s is one of the main barriers in the purchasing decision. Moreover, Hidrue et al. (2011) found driving range to have a significant influence on the adoption of EVs, as well as the necessity of a considerable decrease in battery costs in order for widespread market adoption without a subsidy to occur. Related to this, Franke et al. (2012) mentioned the range of an ICE car to be the prime anchor used by consumers in the evaluation of an (H)EV range.

The large influence of the (H)EV range is caused by drivers experiencing range anxiety, which is defined as a being afraid of battery depletion before arriving at the destination (Tate et al. 2008). Therefore, an increase in driving range of (H)EVs – thereby moving closer to the driving range of ICE cars – is likely to result in lower range anxieties. In turn, this will translate in higher (H)EV adoption rates. Supported by the previously discussed results found in literature, we expect range to be the main factor stimulating (H)EV adoption. Thus:

**H2a: Driving range has a positive effect on (H)EV purchase likelihood**

**H2b: Driving range is the most important factor influencing (H)EV purchase likelihood**

**Charging**

Furthermore, an increase in the development of the charging infrastructure positively affects EV adoption, as was concluded by Sierzchula et al. (2014). Charging infrastructure is mainly associated with the amount of (fast) charging points available throughout the country. Following Bockarjova et al. (2013), this is modeled as detour time, which is the extra driving time needed in order to reach a charging point. An increase in the amount of available charging points will lead to lower detour times experienced by (H)EV drivers. As this detour time decreases, range
anxiety will decrease as well. In turn, this will lead to an increase in the adoption of (H)EV's.

Therefore:

**H3: Detour times have a negative effect on (H)EV purchase likelihood**

Next, as concluded in the studies of Hidrue et al. (2011) and Cheron and Zins (1997), charging time influences (H)EV adoption. Charging time can be separated into two types, namely regular (slow) charging time – e.g. at home or at work – and fast charging time at dedicated fast charging stations along the highways.

Regarding regular (slow) charging time, reduced charging times will increase the mobility of (H)EV drivers. In case of a limited time available to charge the vehicle, one would still be able to substantially recharge the battery, in turn lowering the range anxiety. Reduced fast charging times increase mobility as well, as it allows (H)EV drivers to easily undertake longer journeys which require multiple battery charges without experiencing significant waiting times caused by charging. If charging times decrease to the point of the time needed for refuelling an ICE car, consumers will be indifferent between driving an (H)EV or an ICE car when only regarding this factor. In conclusion, decreasing (fast) charging time will lead to increased (H)EV adoption. It is expected that fast charging times will have a stronger impact than regular charging times. Pressure for quick charging is lower at home or at work, as one often spends a couple of hour here, meaning charging can take longer. However, when visiting a fast charging station the pressure for quick charging is considerably higher. A decrease in fast charging time of i.e. 25 to 10 minutes will substantially benefit the mobility of an (H)EV driver on longer trips. This line of thought results in the following hypotheses:

**H4: Regular charging time has a negative effect on (H)EV purchase likelihood**

**H5a: Fast charging time has a negative effect on (H)EV purchase likelihood**

**H5b: Fast charging time has a stronger negative effect on (H)EV purchase likelihood than regular charging time**

**Price**

Finally, as shown by e.g. Lieven et al. (2011), consumers are sensitive towards the price of an EV. Currently, the price of an (H)EV is considerably higher than the price of a similar ICE car. This is mainly due to the battery costs, which is the key element of the price of an (H)EV (Lieven et al. 2011). A balance should therefore be obtained between a higher-quality battery (extended range) and price. It can be expected that technological developments in the field of (H)EV batteries will lead to vehicles with an attractive battery range as well as price. For now, governments providing financial incentives support lowering this price barrier in (H)EV
adoption. Thus, decreasing prices will positively influence the adoption of (H)EVs. This leads to the final hypothesis:

**H6: (H)EV price has a negative effect on (H)EV purchase likelihood**

Similar to H1, for H2 up and until H6 we are mainly interested in the extent of the hypothesized effect on (H)EV purchase likelihood, in order to be able to distinguish the main factors driving the adoption rate.

All in all, these hypotheses result in the following conceptual model (Figure 2). As can be seen, annual cost savings and range positively influence (H)EV adoption, whereas detour time, charging time, fast charging time and purchase price have a negative effect on (H)EV adoption.

![Conceptual Model showing hypothesized relations between predictive variables and dependent variables](image)

So far, archival data studies have been used mostly in literature, using historical sales data to review the effect of previously imposed government incentives (Chandra et al [2008], Diamond [2009], Gallagher and Muehlegger [2010], Jenn et al [2013]). This causes a gap in literature, since these studies only focused on HEV adoption, and lack focus on the reaction of consumers on possible *future* implementation of varying government (financial) incentives. Moreover, these studies disregarded the influence of other factors on both HEV as well as EV adoption.

The studies of Lieven et al. (2011) and Hidrue et al. (2011) both addressed the latter parts of this gap by performing a stated choice experiment among respondents, identifying the most important factors in EV evaluation and adoption. Yet, not only did Lieven et al. (2011) ignore HEV's, they primarily focused on the influence of price and range in combination with social
preferences on EV adoption, without taking into account other relevant factors such as charging
time, government incentives and detour times. The study of Hidrue et al. (2011) did take into
account additional factors relevant in the purchase process of an EV, yet this study was
conducted between September 2008 and October 2009, and omitted HEV adoption from the
analysis as well.

The (H)EV market developed considerably in the past 5 years, and the European (H)EV adoption
only really commenced in 2013 (McKinsey 2014). Therefore it is assumed that consumer
knowledge regarding (H)EVs has significantly evolved in the past 2 years and has become more
widespread. In turn, the results of Hidrue et al. (2011) – as well as the results of Lieven et al.
(2011) – may turn out different in recent context due to both more knowledgeable respondents
and a more sophisticated (H)EV market.

Finally, Bockarjova et al. (2013) addressed the previously mentioned gap by administering a
stated choice experiment among Dutch respondents, focusing both on hybrid as well as full
electric vehicle adoption. However, this study focuses on willingness-to-pay for an (H)EV and the
corresponding policy implications, instead of consumer reactions to varying government
policies and developments in the (H)EV industry in terms of adoption intentions. This is
important as it allows to provide an all-encompassing outlook of how (H)EV adoption will
progress in the coming years.
Methodology

3.1 Survey design
In order to analyze the impact of the various factors, a survey will be conducted among Dutch respondents. The targeted respondents are chosen as such to be a representative sample of the population, meaning people who are likely to consider purchasing a (hybrid) electric vehicle until the year 2020. The survey will be conducted in Dutch, to ensure all respondents will fully comprehend the survey.

A conjoint analysis has been chosen as the best method to answer the research question. As mentioned by Chiu and Tzeng (1999), stated preference methods are commonly used in marketing. This method is mostly applied to situations involving consumer choice and market forecasting, when data regarding preferences is not easy to obtain or even unavailable – as is the case with (H)EVs (Chiu and Tzeng 1999). Using a conjoint analysis a clear overview of respondents’ (subconscious) attitudes towards purchasing an (H)EV under varying future scenarios can be measured, and the most influential factors on the adoption can be identified.

3.1.1 Measurement of EV adoption
The EV adoption construct will be operationalized as the self-reported likelihood of purchasing an (H)EV in specific scenarios. Since the experiment involves the evaluation of specific products, namely a hybrid electric vehicle and full electric vehicle, it is important to first analyze the participants attitude towards (H)EV's in general, since this attitude could influence the purchase likelihood.

Thus, the experiment will start with general filtering questions to identify whether or not the respondent currently owns a car, in what timeframe he/she is likely to purchase a new car, what the purpose of that new car will be (private, lease), and what the respondents attitude towards electric vehicles is. Furthermore, the environmental attitude of the respondent will be measured using four statements.

Subsequently, the conjoint analysis will be administered. The participant will be presented with a scenario including a combination of attributes, for which he/she has to indicate the purchase likelihood for both an HEV and EV in that specific scenario. The question will look as follows:

*How likely are you to purchase the following cars in this scenario? Assess this consideration separately for both types of cars.*

<table>
<thead>
<tr>
<th></th>
<th>Not likely at all</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Very likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid electric vehicle</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full electric vehicle</td>
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</tbody>
</table>
This exercise will be repeated fifteen times, in order to be able to present each level of an attribute three times to the respondent. The scenarios are balanced in terms of high and low levels of each attribute, as to prevent obvious responses. This will allow us to determine the attributes which are most important to the participant when considering the purchase of an HEV and EV.

At the end of the survey, the respondent will be asked what the most important factors are when considering an (H)EV purchase (‘Imagine you would purchase a hybrid or full electric vehicle. Which factors are most important in your purchase decision?’). The options will include additional factors not included in the scenarios, such as acceleration speed. Finally, more sensitive questions will be asked concerning demographics such as age, gender, educational level and place of residence. To avoid non-response, the answers for these questions will be categorical (Appendix II) (McDaniel and Gates 2012).

3.1.2 Scales

**Purchase intention**

Studies on the use of purchase intention scales show mixed results. For example, a study by Young et al. (1998) states that “intentions almost always provide biased measures (...) sometimes underestimating actual purchasing and other times overestimating actual purchasing”. Carley et al. (2013) mention in their study that “Statements about intent to purchase a product are rarely validated with data on actual purchasing decisions and, when done, the evidence for validity is mixed”. Therefore, they considered a positive response to indicate the consumer’s openness to purchasing a plug-in electric vehicle, instead of an indication of future buying behavior. Studies of e.g. McNeil (1974) and Hsiao et al. (2002) show that the accuracy of forecasts does increase by including purchase intentions, and the study of Wright and MacRae (2007) conclude that purchase intention scales are empirically unbiased.

Following this line of research it was chosen to measure the (H)EV purchase likelihood using a 7-point rating scale. The study of Preston and Colman (2000) backs this methodology, as they found superiority for scales with around seven response categories, which are thus preferred.

**Environmentalism**

Environmentalism has received much attention over the past years as the public has turned its attention to air and water pollution, deforestation and depletion of the ozone layer. Environmental products are promoted extensively, (hybrid) electric vehicles being one of these. Environmentalism has often been abstracted as an attitude (Gray 1985). However, awareness and knowledge of environmental issues plays a role as well, thereby stressing the importance of environmental concern (Banerjee and McKeage 1994). Following the research of Banerjee and
McKeage (1994), who aimed to construct an inclusive conceptualization of environmentalism, the concept Environmentalism is defined as follows:

"1. Beliefs about the relationship of humanity and nature. Environmentalism embraces the belief that humanity and the biophysical environment are interdependent, rejecting the view that humans are intended to dominate nature (Dunlap and Van Leire 1984).
2. Beliefs about the importance of the environment to the self. This involves personal relevance, interest in environmental issues, and feelings of connectedness with the environment.
3. Beliefs that current environmental conditions are a serious problem facing the world (Murch 1974).
4. Beliefs that some radical changes in current lifestyle and economic systems may be required to prevent environmental damage (Catton and Dunlap 1982)." (Banerjee and McKeage 1994).

Gatersleben et al. (2002) studied the relation between environmental attitudes and measurements of direct and indirect energy consumption. Their study concluded that self-reported pro-environmental behavior is related to environmental attitudes, but that it is only weakly related to actual household energy consumption. Thus, respondents might have positive attitudes the environment, yet this often does not translate into corresponding behavior, which is mainly due to the needed effort and loss in comfort. On the contrary, Anable (2005) developed a 105 item scale to assess the influence of environmental attitudes on mode choice behavior, and found that populations with different attitudes indeed have varying mode choice. Schüssler and Axhausen (2011) combined the scales used by Gatersleben et al. (2002) and Kitaruma et al. (1997) – who used a 10 item scale to measure environmentalism – to derive a 25 item scale in order to assess environmentalism of respondents.

After considering time issues and for the sake of simplicity, the methodology used by Carley et al. (2013) to assess environmental attitudes is followed. The statements used by Carley et al. fully reflect the conceptualization of environmentalism as constructed by Banerjee and McKeage (1994). In their study, Carley et al. (2013) composed an environmental additive index to measure the environmentalism of respondents using a 5-point Likert scale. Respondents indicate to what extent they agree or disagree with the following statements:

- "People need to change their lifestyles to protect the environment";
- "Climate change is a serious problem";
- "Climate change is a result of human actions";
- "Environmental problems facing humankind have been greatly exaggerated"

Regarding the first three statements, an answer of "strongly agree" indicates positive environmental attitudes, and is coded two. An answer of "agree" is coded as one. For the last statement, "strongly disagree" indicates positive environmental attitudes, and therefore coded
two. An answer of “disagree” is coded one. Finally, an index indicating the environmental attitude for each respondent is created by averaging the values of each statement.

3.1.3 Attributes

Hensher (2006) showed that respondents in a stated choice experiment generally tend to consider more attributes with decreasing levels per attribute. Furthermore, he also indicated evidence of respondents considering more attributes from the offered set when the attribute's range increased. This means that respondents are likely to ignore fewer attributes when the attributes have only a few levels with great differences between them, making the evaluation of each attribute easier. Moreover, as described by Orme (2012), respondents often find it challenging to deal with more than six attributes. Including more than six attributes can cause an information overload experienced by the respondents, resulting in the deployment of simplification strategies to deal with the challenging task. This can lead to unreliable research outcomes, as the results may place too much focus on the few most important attributes.

Following these studies, six attributes were included in the conjoint analysis, all based on a hybrid and full electric vehicle compared to a regular car (see Table 1). After reviewing existent literature, it can be seen that recent studies found range, price, regular charging time, fast charging time and detour time to be significant predictors of (H)EV adoption. Moreover, governmental (monetary) incentives and fuel prices were shown to be significant predictors. After consulting with experts in the industry, it was deemed highly unlikely that the Dutch government would consider implementing non-financial governmental incentives, such as the use of HOV lanes. Therefore, this factor was excluded from this study. Furthermore, as it is preferred to incorporate a limited number of attributes in a conjoint analysis, fuel price and tax advantages were combined into one attribute, namely annual (operating) cost savings.

The attribute levels were chosen as such they would represent the current state as well as possible future scenarios of each factor. For example, an HEV and EV currently have a battery range of approximately 50 km and 150 km respectively. Due to technological developments, this is expected to rise over the coming years. For annual cost savings, on average one can save about 25-40% per year by driving an electric car compared to an ICE (ANWB 2015). Yet, these savings can fluctuate both up and down, as it is uncertain whether and how much further the tax advantages will decline in the future, and fuel prices are subject to heavy instabilities too. Assumptions can be found in Appendix III.
### Table 1: Attributes and levels included in the Conjoint analysis

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purchase price</strong></td>
<td>The difference in the purchase price of the (hybrid) electric vehicle compared to a similar ICE car</td>
<td>60% higher</td>
<td>45% higher</td>
<td>30% higher</td>
<td>15% higher</td>
<td>Equal (0% higher)</td>
</tr>
<tr>
<td><strong>Annual cost savings</strong></td>
<td>The difference in annual costs of the (hybrid) electric vehicle compared to a similar ICE car, tax advantages and fuel costs included</td>
<td>5%</td>
<td>15%</td>
<td>25%</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>The amount of kilometres the (hybrid) electric vehicle can drive using a fully loaded battery, under normal circumstances</td>
<td>50 km</td>
<td>150 km</td>
<td>250 km</td>
<td>500 km</td>
<td>750 km</td>
</tr>
<tr>
<td><strong>Charging time</strong></td>
<td>The time needed to fully charge the battery of a (hybrid) electric vehicle, at home or at work</td>
<td>8 hours</td>
<td>6 hours</td>
<td>4 hours</td>
<td>2 hours</td>
<td>1 hour</td>
</tr>
<tr>
<td><strong>Fast charging time</strong></td>
<td>The time needed to charge the battery of a (hybrid) electric vehicle, at special stations along the highways</td>
<td>25 min</td>
<td>20 min</td>
<td>15 min</td>
<td>10 min</td>
<td>5 min</td>
</tr>
<tr>
<td><strong>Detour time</strong></td>
<td>The extra time required to drive with a (hybrid) electric vehicle to reach a charging point</td>
<td>20 min</td>
<td>15 min</td>
<td>10 min</td>
<td>5 min</td>
<td>0 min</td>
</tr>
</tbody>
</table>

**3.1.4 Collection**

Each respondent will indicate the purchase probability of an HEV and EV fifteen times. The scenarios will be presented in random order in order to avoid any bias. It is planned to collect a minimum of 150 responses.

A test of the survey has been conducted among 15 respondents. Short interviews with the pilot-respondents were held afterwards to optimize the design on all aspects such as content, form, layout, clarity, wording and sequence. The survey was adjusted according to the results of the received feedback. The question regarding the function of the car was adjusted to improve clarity. The question asking whether the respondent would drive a lease car privately as well and the question requiring income specification were deleted from the survey.

**3.2 Sampling**

As was shown in the study by Egbue and Long (2012), differences exist in the interest in (H)EV’s and knowledgeability concerning sustainability among various age groups. The study showed that people over the age of 25 score significantly higher on both variables.

Therefore, it is intended to have a sample of respondents over the age of 25 who will be asked to complete the survey. This target group is expected to either currently own an ICE car, an (H)EV, or not own a car at all. Also, they are likely to purchase a car in the coming five years, either for
private or business purpose. Moreover, this group is expected to be relatively knowledgeable concerning sustainability and the possibility of driving an (H)EV (Egbue and Long 2012). People below the age of 21 as well as students will not be targeted, as it is expected they will not be knowledgeable enough regarding the possibilities and features of (H)EV's, and/or are not expected to purchase a car for their own use in the upcoming years.

It is aimed to target mostly respondents owning a car, as they will be more aware of the costs involved in purchasing and owning a car, meaning they are expected to be able to realistically trade off the financial aspects in the scenarios. Non-respondents are expected to differ from respondents in terms of less knowledgeability concerning driving (H)EV’s, the general costs and obligations associated with buying/owning a car, and a lack of interest in the subject of (hybrid) electric vehicles and sustainability. This does not threaten validity to a large extent, since it can be implied that these non-respondents are not likely to adopt an (H)EV in any case due to their small knowledgeability and lack of interest.

Personal networks consisting of friends, relatives, neighbors and acquaintances will be targeted through personal emails in order to gain respondents. Furthermore, social network sites such as LinkedIn will be used to collect more responses, for example by posting the survey in automotive interest groups. Moreover, (H)EV owners will be targeted by posting invitations to participate in the survey at charging stations as well as private home addresses. Finally, employees of a large Dutch grid operator and their network will be asked to complete the experiment. This is type of sampling is called convenience sampling. A convenience sample is defined as a sample “that is simply available to the researcher by virtue of its accessibility” (Bryman, 2011). Although external validity might be reduced due to convenience sampling, the sample is largely diversified as it consists of (recent) graduates and professionals of mostly middle class, with expected varying attitudes and interests in electric driving. Therefore, the sample will be representative of the larger part of the population who are likely to purchase an (H)EV in the coming years for either business or private purpose.

3.3 Interviews

In addition to the survey, it is envisioned to conduct interviews with experts in the (H)EV market, to be able to validate and support our quantitative findings. These interviews will be short and open, touching upon the main motivations and barriers of customers encountered by the experts in the (H)EV sales process.
Data

The data was collected in May 2015, using the previously described convenience sampling. The survey lasted 8-10 minutes on average, and was started by 532 respondents. 307 of these respondents completed the survey, bringing our sample to 307 valid responses, double the amount of intended respondents. Besides asking the question on the probability of purchasing an HEV and EV in varying scenarios, questions were asked regarding current vehicle possession, vehicle type, main car use, expected next car purchase, as well as questions concerning attitudes towards the environment and electric driving. The sample is fairly representative of the Dutch population, taking in mind the targeting of car owners over the age of 25 (see Table 2).

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Sample Frequency</th>
<th>Sample Percentage</th>
<th>Dutch population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car owner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>265</td>
<td>86.3%</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>42</td>
<td>13.7%</td>
<td></td>
</tr>
<tr>
<td>Type of car</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid</td>
<td>36</td>
<td>13.6%</td>
<td>0.5%a</td>
</tr>
<tr>
<td>Electric</td>
<td>18</td>
<td>6.8%</td>
<td>0.1%a</td>
</tr>
<tr>
<td>Other</td>
<td>211</td>
<td>79.6%</td>
<td>99.4%a</td>
</tr>
<tr>
<td>Main car use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>215</td>
<td>70.0%</td>
<td></td>
</tr>
<tr>
<td>Lease</td>
<td>92</td>
<td>30.0%</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>184</td>
<td>59.9%</td>
<td>49.50%b</td>
</tr>
<tr>
<td>Female</td>
<td>123</td>
<td>40.1%</td>
<td>50.50%b</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;21 years</td>
<td>13</td>
<td>4.2%</td>
<td>11%b</td>
</tr>
<tr>
<td>21-30 years</td>
<td>72</td>
<td>23.5%</td>
<td>12%b</td>
</tr>
<tr>
<td>31-40 years</td>
<td>54</td>
<td>17.6%</td>
<td>13%b</td>
</tr>
<tr>
<td>41-50 years</td>
<td>75</td>
<td>24.4%</td>
<td>15%b</td>
</tr>
<tr>
<td>51-60 years</td>
<td>76</td>
<td>24.8%</td>
<td>14%b</td>
</tr>
<tr>
<td>&gt;60 years</td>
<td>17</td>
<td>5.5%</td>
<td>24%b</td>
</tr>
<tr>
<td>Education Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary education</td>
<td>1</td>
<td>0.3%</td>
<td>10.9%b</td>
</tr>
<tr>
<td>Practical education</td>
<td>1</td>
<td>0.3%</td>
<td>21.8%b</td>
</tr>
<tr>
<td>VMBO/MAVO</td>
<td>6</td>
<td>2.0%</td>
<td></td>
</tr>
<tr>
<td>HAVO</td>
<td>11</td>
<td>3.6%</td>
<td>8.7%b</td>
</tr>
<tr>
<td>VWO</td>
<td>9</td>
<td>2.9%</td>
<td></td>
</tr>
<tr>
<td>MBO</td>
<td>44</td>
<td>14.3%</td>
<td>30.6%b</td>
</tr>
<tr>
<td>HBO</td>
<td>123</td>
<td>40.1%</td>
<td>26.8%b</td>
</tr>
<tr>
<td>WO</td>
<td>107</td>
<td>34.9%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>1.6%</td>
<td>1.2%b</td>
</tr>
<tr>
<td>Living area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large city</td>
<td>114</td>
<td>37.1%</td>
<td></td>
</tr>
<tr>
<td>Small city</td>
<td>90</td>
<td>29.3%</td>
<td></td>
</tr>
<tr>
<td>Town</td>
<td>86</td>
<td>28.0%</td>
<td></td>
</tr>
<tr>
<td>Countryside</td>
<td>17</td>
<td>5.5%</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Sample statistics. aSource: www.rvo.nl, bSource: www.cbs.nl
To measure environmental attitudes and interest in electric driving a 5-point Likert scale was used. For measuring the purchase probability of an HEV and EV, a 7-point rating scale was used. As stated by Nunnaly (1978), a reliability coefficient of 0.7 or higher is acceptable in literature. Results of the reliability analysis in Table 3 prove all three rating scales to have high internal consistency.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Cronbach Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmentalism</td>
<td>0.731</td>
</tr>
<tr>
<td>Probability of purchasing HEV</td>
<td>0.938</td>
</tr>
<tr>
<td>Probability of purchasing EV</td>
<td>0.936</td>
</tr>
</tbody>
</table>

Table 3: Cronbach Alpha’s for Scales

As described in section 3.1.2, an environmentalism index has been created to measure potential differences in environmental attitude among respondents. As can be seen from Table 4, no significant differences exist between car owners and non-car owners in terms of environmentalism or interest in electric driving, or between environmental attitudes of lease and private drivers. However, a significant difference ($\alpha = 0.01$) does exist in the interest in electric driving between lease and private drivers. This could result in higher stated (H)EV purchase likelihoods among lease drivers than among private drivers, and will therefore be tested in our analysis.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmentalism</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entire sample</td>
<td>1.08</td>
<td>0.54</td>
<td>1.00</td>
</tr>
<tr>
<td>Car owners</td>
<td>1.08</td>
<td>0.54</td>
<td>1.00</td>
</tr>
<tr>
<td>Lease drivers</td>
<td>1.11</td>
<td>0.53</td>
<td>1.25</td>
</tr>
<tr>
<td>Private drivers</td>
<td>1.06</td>
<td>0.55</td>
<td>1.00</td>
</tr>
<tr>
<td>Interest in Electric Driving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entire sample</td>
<td>1.13</td>
<td>0.77</td>
<td>1.00</td>
</tr>
<tr>
<td>Car owners</td>
<td>1.12</td>
<td>0.78</td>
<td>1.00</td>
</tr>
<tr>
<td>Lease drivers</td>
<td>1.33***</td>
<td>0.79</td>
<td>2.00</td>
</tr>
<tr>
<td>Private drivers</td>
<td>1.04***</td>
<td>0.75</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 4: Sample attitudes towards Environment and Electric Driving. *** Statistically significant at $\alpha=0.01$

The six predictive variables are significantly correlated to each other, although some variables show considerably stronger correlations. The strongest correlation exists between annual cost savings and fast charging time (-0.549), implying that with increasing annual cost savings due to driving an (H)EV, respondents decrease their requirements regarding fast charging time. Moreover, the positive correlation between price difference and annual cost savings indicates that monetary advantages in either annual cost savings or price difference due to driving an (H)EV allow the other factor to be less beneficial for the same stated purchase intention. Counter intuitively, charging time and detour time are positively correlated to price, meaning a higher price difference between and ICE and an (H)EV allow charging and detour times to be higher.
One would expect the exact opposite relation, where a higher price difference would require charging and detour times to be lower. Finally, range and fast charging time confirm logical expectations in terms of the strong negative correlation between the two variables. This negative relationship shows acceptance of longer fast charging times with increasing range, and vice versa. This meets anticipations, as with larger ranges the need for charging decreases. See Appendix IV for more detailed information. As moderately strong correlations are found between several variables, multi-collinearity checks will be performed.
Results

Analysis of the data was done using two models, in order to retrieve an extensive overview of the results. These include a utility estimation model as well as a multiple regression model, and are discussed below.

5.1 Utility estimation Model

Firstly, part-worth estimates, or utility scores, for each individual factor level used in the conjoint analysis were calculated. The resulting utility scores resemble regression coefficients, and represent the preference per each factor level. Thus, a higher positive value indicates a greater preference. However, as the utility scores have an arbitrary origin, they are interval data and do therefore not allow for ratio operations and cannot be compared across factors (Orme 2010). Furthermore, average importance scores are provided for each factor, thereby indicating the essential features in the decision of (H)EV purchase likelihood.

Malhotra and Birks (2007) define the basic utility estimation function as:

\[ U(X) = \sum_{i=1}^{m} \sum_{j=1}^{k_i} \alpha_{ij} x_{ij} \]

where

\( U(X) = \text{overall utility of an alternative} \)
\( \alpha_{ij} = \text{the part–worth contribution with the } j^{th} \text{ level of the } i^{th} \text{ attribute} \)
\( k_i = \text{number of levels of attribute } i \)
\( m = \text{number of attributes} \)

Thereafter, the importance of each attribute \( (I_i) \) is defined in terms of the part-worths \( (\alpha_{ij}) \) across the levels of that specific attribute:

\[ I = \{ \max(\alpha_{ij}) - \min(\alpha_{ij}) \} \text{ for each } i \]

Next, we normalize the attribute’s importance to be able to determine its importance relative to other attributes \( (W_i) \):

\[ W_i = \frac{I_i}{\sum_{i=1}^{m} I_i} \]

So that

\[ \sum_{i=1}^{m} W_i = 1 \]

5.1.1 Hybrid Electric Vehicles

The correlation coefficients of the HEV model, \( R=0.97 \) and Kendall’s tau = 0.91 (both significant at \( \alpha=0.01 \)), indicate a strong linear relationship between the six predictive variables included in the conjoint analysis (price difference, annual cost savings, range, charging time, fast charging
time and detour time) and the dependent variable, being the likelihood of buying a hybrid electric vehicle. However, one should note this high correlation might be due to the fact that the number of parameters is close to the number of profiles which were rated. This can inflate the correlations between the estimated and observed scores. Normally, one should add holdout profiles to the test in order to provide a more accurate indication of the model fit.

As can be seen from Table 5, price difference between an HEV and an ICE car shows to be the most influential factor on the intention of buying an HEV, as is proven by the large averaged importance score and the large positive utility estimate. Range is strongly positively correlated to HEV purchase likelihood, and the second most important factor as indicated by the second highest average importance score. Finally, annual cost savings due to driving an HEV proves to be a moderately important factor, as is supported by the moderate and positive relationship between cost savings and HEV purchase likelihood. See Appendix V for extensive results.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Averaged Importance Score for HEVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price difference</td>
<td>42.09</td>
</tr>
<tr>
<td>Annual costs savings</td>
<td>11.98</td>
</tr>
<tr>
<td>Range</td>
<td>32.01</td>
</tr>
<tr>
<td>Charging time</td>
<td>2.92</td>
</tr>
<tr>
<td>Fast charging time</td>
<td>6.81</td>
</tr>
<tr>
<td>Detour time</td>
<td>4.17</td>
</tr>
</tbody>
</table>

Table 5: Averaged Importance Scores for HEVs

5.1.2 Full Electric Vehicles

The correlation coefficients of the EV model, $R=0.96$ and Kendall’s tau = 0.81 (both significant at $\alpha=0.01$), again indicate a strong linear relationship between the independent variables and the likelihood of buying a full electric vehicle. As mentioned before though, this correlation should be regarded with caution due to the fact that the number of parameters is close to the number of profiles which were rated, resulting in a possible inflation of the correlations between the estimated and observed scores.

As can be seen from Table 6, contrary to HEV results, range appears to be the most influential factor in the consideration of purchasing an EV. Almost equally important in an EV purchase consideration is the price difference with an ICE, followed again by the annual cost savings when driving an EV. See Appendix V for all-encompassing results for the part-worth analysis of EV purchase likelihood.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Averaged Importance Score for EVs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price difference</td>
<td>35.85</td>
</tr>
<tr>
<td>Annual cost savings</td>
<td>10.72</td>
</tr>
<tr>
<td>Range</td>
<td>42.18</td>
</tr>
<tr>
<td>Charging time</td>
<td>3.27</td>
</tr>
<tr>
<td>Fast charging time</td>
<td>5.48</td>
</tr>
<tr>
<td>Detour time</td>
<td>3.51</td>
</tr>
</tbody>
</table>

Table 6: Averaged Importance Scores for EVs

These results imply that range anxiety is higher for a full electric vehicle than for a hybrid electric vehicle, as can logically be expected due to the possibility of using the combustion engine after the battery of an HEV has been depleted. For both HEV’s and EV’s, price difference, annual cost savings and range are by far the three most important factors when considering a purchase, while both slow and fast charging times as well as detour times do not appear to be of noticeable importance.

5.2 Multiple regression analysis Model

Next, a hierarchical multiple regression was performed. The predictive variables were assumed to be continuous, meaning the purchase likelihood as indicated by respondents on the 7-point rating scale is analogous to purchase likelihood ratings from i.e. 0 to 100. Therefore, the dependent variables were recoded into a scale of 0 to 100, representing the (H)EV purchase likelihood in percentages. The multiple regression models for HEV and EV purchase likelihood are as follows:

\[
HEV_{purchase \ likelihood} = \beta_0 + \beta_{price} \times price + \beta_{costs} \times costs + \beta_{range} \times range + \beta_{charge} \times charge + \beta_{fast \ charge} \times fast \ charge + \beta_{detour} \times detour + \epsilon
\]

\[
EV_{purchase \ likelihood} = \beta_0 + \beta_{price} \times price + \beta_{costs} \times costs + \beta_{range} \times range + \beta_{charge} \times charge + \beta_{fast \ charge} \times fast \ charge + \beta_{detour} \times detour + \epsilon
\]

5.2.1 Hybrid Electric Vehicles

The data was thoroughly checked to ensure the assumptions of linear regression are met. For the likelihood of purchasing an HEV, the dataset is free from error terms (Durbin Watson = 1.847) and free from multi-collinearity (correlations all below 0.549, VIF all below 3.247 and tolerance all over 0.308). One case is diagnosed which deviates strongly from the predicted value (HEV purchase likelihood is 87.5, while predicted value is 14.98). However, as the value of Cook’s distance has a maximum of 0.005, this data point was not identified as an influential case. Moreover, the histogram and normal probability plot show the dependent variable to be relatively normally distributed, as supported by the Skewness statistic of 0.457 (see Appendix
VI). Finally, the assumption of homoscedasticity is checked by reviewing the scatterplot of the regression standardized predicted value and regression standardized residual. As can be seen the plot displays a clear pattern, indicating a possible violation of this assumption. Therefore, White’s test is performed to formally check this assumption. As $LM < \chi^2 (LM = 918, \chi^2 = 4813)$, heteroscedasticity cannot be confirmed (see Appendix VI for detailed results).

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
<th>Std. Error</th>
<th>$R^2$ change</th>
<th>P-value change</th>
<th>P-value Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Control variables only</td>
<td>0.224</td>
<td>0.050</td>
<td>0.048</td>
<td>25.168</td>
<td>0.050</td>
<td>0.000***</td>
<td>0.000***</td>
</tr>
<tr>
<td>2 Control &amp; predictive variables</td>
<td>0.457</td>
<td>0.209</td>
<td>0.206</td>
<td>22.988</td>
<td>0.159</td>
<td>0.000***</td>
<td>0.000***</td>
</tr>
</tbody>
</table>

Table 7: HEV Regression Model Summary. *** Statistically significant at $\alpha=0.01$

As can be seen from Table 7, the final HEV model – model 2 – is statistically significant, and 20.9% of the variance in performance is explained by the independent variables, indicating a moderate fit of the model. As the $R^2$ change is 0.159 for model 2, this indicates that the predictive variables price difference, annual cost savings, range, charging time, fast charging time and detour time account for 15.9% of the variance in performance, whereas 5% of the variance in performance is explained by the control variables.

Table 8 shows the regression coefficients for the independent variables. Regarding the control variables, car type, car use, next car purchase, age, education, interest in electric driving and environmentalism all appear to have a significant effect on the likelihood of purchasing an HEV, where the current car type (EV, HEV or ICE) has the largest influence on this purchase intention, followed by the use of the car (private/lease). The former indicates that current (or past) ownership of an EV or HEV leads to a higher purchase likelihood of a similar car in the future, while current ICE owners are less likely to purchase an HEV in the future. This result is supported by the significant difference between mean HEV purchase likelihood between the groups ($F=114.985, p=0.000$). A Tukey post hoc test revealed that the HEV purchase likelihood is statistically significantly different between all three groups.

Concerning the variable car use, lease drivers are more likely to adopt an HEV than private drivers ($F=91.479, p=0.000$). This is likely caused by the Dutch tax advantages, which are highly beneficial for lease drivers when driving an HEV. This is supported in our interviews, as both interviewees confirmed that the majority of the (H)EV’s are sold to lease drivers, who’s main motivation for the purchase is of monetary nature.

Considering predictive variables, not surprisingly only price difference, range and annual cost savings show to have a significant effect ($\alpha=0.01$) on the likelihood of purchasing an HEV, while
fast charging time has a significant effect on a 5% level. The specific results are discussed below, elaborating on the most important factors first.

**Range** (*H*2*a*: Driving range has a positive effect on (H)EV purchase likelihood, *H*2*b*: Driving range is the most important factor influencing (H)EV purchase likelihood*)

Range has a strong positive influence on the purchase probability of an HEV, confirming the expectation as formulated in hypothesis H2a. However, hypothesis H2b is not supported, as for HEV’s price shows to have the largest influence on the purchase likelihood, instead of range. This is likely caused by the possibility of extending the range of the vehicle by switching to the combustion engine, thereby limiting range anxiety. When analysing the answers to the survey question asking directly which factors are most important when considering to purchase an (H)EV, the same result is found. Namely, range is mentioned most often as a key factor. Moreover, this outcome is backed in the interviews with both interviewees, who argue the range to be one of the main factors in (H)EV adoption.

**Price** (*H*6*: (H)EV price has a negative effect on (H)EV purchase likelihood*)

Price has a strong negative relation with the purchase likelihood of an HEV, supporting hypothesis H6. The variable even has the largest influence on HEV adoption, contrary to what was expected (being range). Currently, HEV prices still lay well above the price levels of similar ICE cars. Therefore, if HEV prices move closer to price levels of comparable ICE cars, the adoption of HEV’s is expected to increase. These findings are supported by the direct survey question as well, since price was mentioned almost equally often as range as an important factor to consider in a purchase decision. Also, in the interviews price levels were mentioned to be one of the main factors limiting (H)EV adoption (Interviewee 1 and Interviewee 2). Moreover, Interviewee 2 mentioned consumers focus on the Total Cost of Ownership of the vehicle – which must not be higher than those of an ICE – since subsidies started to decline in 2014.

**Annual cost savings** (*H*1*: Annual cost savings have a positive effect on (H)EV purchase likelihood*)

Besides this, annual cost savings show to have a moderately positive relationship with HEV purchase likelihood, thereby verifying hypothesis H1. Although price and range have a stronger effect on adoption, annual cost savings appear to have a significant influence as well. Thus, if tax advantages will increase and/or oil prices will rise, this will lead to a rise in HEV sales. Inversely, if either or both tax advantages and oil prices will decline, driving an HEV is less beneficial compared to an ICE and will therefore result in lower HEV sales. For our direct survey question annual cost savings were separated into fuel prices and annual tax advantages. The former was mentioned more often than the latter, and added together these two factors were mentioned almost equally often as range and price, thereby supporting the regression results. In the interviews fiscal benefits were mentioned as one of the main drivers for (H)EV adoption, even
though HEV owners rarely fully use the battery of the vehicle: “... But how often do they actually drive electrically? Almost never.” (Interviewee 1).

**Charging time** *(H4: Regular charging time has a negative effect on (H)EV purchase likelihood, H5a: Fast charging time has a negative effect (H)EV purchase likelihood, H5b: Fast charging time has a stronger negative effect on (H)EV purchase likelihood than regular charging time)*

Based on the results of our regression analysis, hypothesis H4 is rejected. Although charging time does indeed show to have a negative effect on (H)EV purchase likelihood, it is not a significant effect. However, hypothesis H5a is accepted, since fast charging time shows a negative relation with our dependent variable, albeit weakly. Also, the effect of fast charging time is stronger than the effect of regular charging time, thereby accepting hypothesis H5b. This confirms our expectations of lower time pressure during regular charging as opposed to the higher time pressure experienced during fast charging. Another explanation for the insignificant influence of charging time may be found in HEV drivers actually not having to charge their vehicle at all, as they can always drive using the combustion engine. Moreover, the results were validated in our interviews. It was stated that the current implications for electric driving regarding the charging infrastructure are still manageable (Interviewee 1). Nonetheless, Interviewee 1 states that the charging infrastructure – which incorporates both types of charging – can turn into a barrier if (H)EV adoption becomes widespread but nationwide charging infrastructure does not evolve suitably.

**Detour time** *(H3: Detour time have a negative effect on (H)EV purchase likelihood)*

Finally, all variables show plausible signs with the exception of detour time. Moreover, the coefficient shows not to be significant, both reasons for rejecting H3. The weakly positive coefficient implies that longer detour times – thus less sophisticated infrastructure in terms of charging poles – will lead to an increase of HEV adoption. This result may be a consequence of misunderstanding of the concept or methodological shortcomings. It could be the case respondents either did not fully comprehend the possibility of having to drive further to reach a charging pole, or respondents did not take into account detour time at all, but only focused on the other variables included.

See Appendix VIII for detailed results regarding the answers to our direct question asking respondents to list the most important factors in a (H)EV purchase decision.
Table 8: Regression coefficients for HEV purchase likelihood

<table>
<thead>
<tr>
<th>Variables</th>
<th>Standardized Beta coefficient</th>
<th>t-statistic</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car type</td>
<td>-0.107</td>
<td>-6.799</td>
<td>0.000***</td>
</tr>
<tr>
<td>Car use</td>
<td>0.099</td>
<td>6.592</td>
<td>0.000***</td>
</tr>
<tr>
<td>Next car purchase</td>
<td>0.041</td>
<td>2.799</td>
<td>0.005***</td>
</tr>
<tr>
<td>Age</td>
<td>-0.043</td>
<td>-2.947</td>
<td>0.003***</td>
</tr>
<tr>
<td>Education</td>
<td>0.042</td>
<td>2.908</td>
<td>0.004***</td>
</tr>
<tr>
<td>Interest Electric Driving</td>
<td>0.077</td>
<td>4.637</td>
<td>0.000***</td>
</tr>
<tr>
<td>Environmentalism</td>
<td>0.045</td>
<td>2.870</td>
<td>0.004***</td>
</tr>
<tr>
<td>Range</td>
<td>0.231</td>
<td>14.283</td>
<td>0.000***</td>
</tr>
<tr>
<td>Price difference</td>
<td>-0.299</td>
<td>-11.751</td>
<td>0.000***</td>
</tr>
<tr>
<td>Annual cost savings</td>
<td>0.088</td>
<td>3.903</td>
<td>0.000***</td>
</tr>
<tr>
<td>Charging time</td>
<td>-0.020</td>
<td>-0.897</td>
<td>0.370</td>
</tr>
<tr>
<td>Fast charging time</td>
<td>-0.045</td>
<td>-2.222</td>
<td>0.026**</td>
</tr>
<tr>
<td>Detour time</td>
<td>0.031</td>
<td>1.565</td>
<td>0.118</td>
</tr>
</tbody>
</table>

*** Statistically significant at α=0.01, **Statistically significant at α=0.05, *Statistically significant at α=0.10

The results of the HEV regression are all in accordance with the findings of the utility estimation as performed in section 5.1.1, where price was found to be the most important factor followed by range. Both tests indicate price, range and annual cost savings to be the three most important factors in the consideration of buying an HEV.

Furthermore, reflecting on the significant β-coefficient of the variable car use, we were interested whether private and lease drivers display different purchase likelihoods under varying factor levels (See Appendix IX for results of all variables). A statistically significant difference was found for general HEV purchase likelihood between both groups as determined by the one-way ANOVA (F = 91.479, p = .000). Yet, Figure 3 shows that although lease drivers indeed consistently show higher purchase likelihood for HEV’s, the interpolated lines for both subgroups show the same development over varying factor levels. In Figure 3 it can be seen that an increase to a range of approximately 200 km will increase HEV adoption, after which no considerable rises (and even a slight decline) are experienced until a range of about 500 km is reached. If HEV’s will have a battery range of 500 km or over – which lies close to the range of an ICE – HEV adoption is likely to increase by 1.5 times.
Following this result, it was expected that price and range may interact, implying that lower price ranges might decrease range barriers, and vice versa higher ranges will decrease price barriers.

Figure 4b shows the effect of price differences on HEV purchase likelihood for varying range levels. It can be noticed that, naturally, higher ranges lead to higher HEV purchase likelihood under all price levels. However, more interestingly, while a change from a 15% difference between an HEV and an ICE to a 0% difference does not lead to considerable increase in HEV purchase likelihood for ranges until 500 km, a sharp increase in HEV adoption will be experienced for ranges of 750 km. In other words, if an HEV has a range of 750 km, and prices decrease to the same level as ICE cars, this will lead to considerably higher adoption rates of HEV's.

Moreover, as graphically displayed in Figure 4b, zero price difference between an ICE and HEV will lead to a considerably higher HEV adoption compared to cases where an HEV remains more expensive than an ICE. Besides this, HEV purchase likelihood shows a much steeper rise with increasing range for zero price difference than under other price difference levels.
5.2.2 Full Electric Vehicles

Regarding the linear regression assumptions for the likelihood of purchasing an EV, the dataset is free from error terms (Durbin Watson = 1.842), and does not show signs of multi-collinearity (correlations all below 0.549, VIF all below 3.247 and tolerance all over 0.308). Four cases were diagnosed which deviated strongly from the predicted value (EV purchase likelihood are 87.5, while the predicted values vary from 17.78 to 20.40). However, as the value of Cook’s distance for the dataset has a maximum of 0.004, these data points were not considered to be influential cases. Besides this, the histogram and normal probability plot display a normal distribution of our dependent variable, which is once more supported by the Skewness statistic of 0.769. Finally, homoscedasticity is reviewed using the scatterplot of the regression standardized predicted value and regression standardized residual. As was the case before, the plots indicate a clear pattern, possibly indicating heteroscedasticity. White’s test show $LM < \chi^2$ ($LM = 1312, \chi^2 = 4813$), thus heteroscedasticity cannot be confirmed (See Appendix VII for detailed information).
Table 9: EV Regression Model Summary. *** Statistically significant at α=0.01

In Table 9 the final EV model – model 2 – is displayed, which proves to be statistically significant. 30.1% of the variance in performance is explained by the independent variables, thereby indicating a moderately good fit of the model. As the $R^2$ change is 0.214 for model 2, this indicates that the predictive variables of interest account for 21.4% of the variance in performance, whereas only 8.7% of the variance in performance is explained by the control variables.

Table 10 shows the regression coefficients for all independent variables. The control variables car type, car use, age, education, interest in electric driving and environmentalism show to have a significant effect on the likelihood or purchasing an EV, while for HEV purchase likelihood car type, car use, next car purchase, education, age, interest in electric driving and environmentalism showed to have significant effects. These differences may be due to the different nature and implications of driving an EV in contrast to an HEV, for instance regarding the previously mentioned consequences of battery depletion. Moreover, the current type of car indicates that present ownership of an EV or HEV results in higher EV purchase likelihood. This result is supported by the significant difference between mean HEV purchase likelihood between groups (F=85.310, p=0.000). The subsequent Tukey post hoc test revealed that the HEV purchase likelihood is statistically significantly different between all three groups.
The variable Interest in electric driving shows to have a stronger relation with EV purchase likelihood than HEV purchase likelihood. This is possibly caused by the stronger deviation from ICES and novelty of EVs than HEVs. Another plausible explanation may be a difference in knowledgeable, as more interest in electric driving is likely to cause higher knowledgeable regarding EVs, in turn increasing the EV purchase likelihood.

When considering the predictive variables, analogous to the HEV model only price difference, range and annual cost savings show to have a significant effect ($\alpha=0.01$) on the likelihood of purchasing an EV, while fast charging time is again significant on a 5% level.

**Range** *(H2a: Driving range has a positive effect on (H)EV purchase likelihood, H2b: Driving range is the most important factor influencing (H)EV purchase likelihood)*

From the results of the EV model it can be seen that range has the largest influence on the purchase likelihood, thereby presenting evidence for both hypothesis H2a and H2b. Range not only has a much stronger influence on adoption in the EV model than in the HEV model, it is also more important than price – contrary to the HEV model. This is likely due to the higher range anxiety experienced for EVs, as for this type of vehicle no possibility exists to extend the range using a combustion engine.

This result is supported in the conducted interviews, where it was stated that one of the major factors limiting (H)EV adoption is the range of the vehicles (Interviewee 1 and Interviewee 2). Interviewee 2 argues consumers will not worry about this factor starting from ranges of 800 km and above. Furthermore, our direct survey question asking shows similar results, as range was mentioned most often as a key factor in an (H)EV purchase consideration.

**Price** *(H6: (H)EV price has a negative effect on (H)EV purchase likelihood)*

Price difference between an EV and ICE is strongly negatively related to the purchase of an HEV, which confirms hypothesis H6. This strong negative relation implies that a drop in prices will cause a significant increase in EV sales. During the interviews price as well as total cost of ownership have been mentioned as major factors in (H)EV purchase considerations, thereby validating the regression results (Interviewee 1 and Interviewee 2). Interviewee 1 believes consumers are willing to buy a second-hand (used) EV as an additional second car in the family, if these were to be priced around €15,000. Additionally, the results of the direct survey questions support our findings too, since price was mentioned second most often after range.

**Annual cost savings** *(H1: Annual cost savings have a positive effect on (H)EV purchase likelihood)*

Next, annual cost savings appear to have a moderately positive relationship with EV purchase likelihood as well, confirming our expectation as formulated in hypothesis H1. Thus, if either or both fuel prices and tax advantages increase, this will lead to higher EV adoption, and vice versa. This result is supported by the findings of our direct survey question, where fuel prices and
annual tax advantages together are mentioned to be important factors equally often as range and price. Furthermore, Interviewee 1 states to already have noticed a decline in the interest for electric driving of lease riders since the decrease in tax advantages last year (about €100 per month). Also, subsidies are believed to be vital in large scale EV adoption, as these counter the high purchase costs of EVs. "If the subsidies were to be abolished, we would probably sell 70% less" (Interviewee 2). Besides this, he mentioned the necessity to not only provide financial incentives to lease drivers, but also introduce additional subsidies for private EV drivers in order to be able to reach the goal set by the government (1,000,000 electric vehicles in 2025, Rijksoverheid 2014).

**Charging time** *(H4: Regular charging time has a negative effect on (H)EV purchase likelihood, H5a: Fast charging time has a negative effect (H)EV purchase likelihood, H5b: Fast charging time has a stronger negative effect on (H)EV purchase likelihood than regular charging time)*

Moreover, hypothesis H4 is rejected, since the effect of regular charging time on EV purchase likelihood is not significant. Once more, hypotheses H5a and H5b are supported by the EV model, based on the significantly negative coefficient of fast charging time, which is larger than the coefficient of regular charging time. This indicates again the time pressure of charging is larger for fast charging than for regular charging, since fast charging is needed during longer drives requiring quick resumption of the commute.

Our regression results are supported by our interviews. Interviewee 1 mentions the current charging infrastructure to be adequate, however stresses the need for continuing the development of infrastructure to match the future increase in (H)EVs. Moreover, Interviewee 2 highlights the importance of fast charging, and mainly sees development of fast charging en route as a stimulating factor.

**Detour time** *(H3: Detour time have a negative effect on (H)EV purchase likelihood)*

Finally, counterintuitive and non-significant results are again found for detour time, causing a lack of evidence for hypothesis H3. Our regression results show detour time to have a positive relationship with EV purchase likelihood, thereby implying less developed charging infrastructure – thus longer detour times – to be preferred. As discussed before, this could be a result of misunderstanding of the concept or methodological shortcomings.

See Appendix VIII for detailed results regarding the answers to our direct question asking respondents to list most important factors in a (H)EV purchase decision.

The overall results for our EV model support the findings of the utility estimation as performed in section 5.1.2, where range was found to be the key factor, closely followed by range. Furthermore, annual cost savings are moderately important in the consideration of buying an EV.
As car use showed to have a significant effect on EV purchase likelihood, albeit weaker than in the HEV model, it was reviewed whether differences between private and lease drivers exist in terms of these EV purchase likelihoods under fluctuating variable levels. A one-way ANOVA showed a statistically significant difference for general EV purchase likelihood between both groups (F = 58.026, p = .000). In Figure 6 the relationship between range and EV purchase likelihood for private and lease drivers is displayed (see Appendix X for an overview of all factors). Comparable to HEV's, the purchase likelihood of lease drivers is constantly higher than of private drivers. However, once again no vast differences can be found in the general tendency of purchase likelihood over an increasing range. Similar to HEV's, an increase to a battery range of 200 km will lead to an increase in EV adoption, after which no considerable rises are experienced until a range of about 500 km is reached. If EV’s will have a battery range of 500 km or over – similar to the range of an ICE – EV adoption is expected to show a considerable increase.

![Figure 5: Range and EV Purchase likelihood for Private and Lease drivers. A slight decrease is seen between a range of 400 and 600 km. Car manufacturers should aim to produce EV's with a range until 200 km or over 600 km.](image)

As for HEV’s, it was subsequently checked whether an interaction between range and price was present for EV purchase likelihood. As shown in Figure 6a, a range of 750 km of EV’s will consistently lead to higher EV purchase likelihoods under varying price difference levels. Additionally, for ranges until 500km a decrease in price difference will not lead to vastly higher
EV purchase likelihoods, yet it does do so for a range of 750 km. More specifically, if EV’s have a range of about 750 km and the price difference between an EV and ICE decreases from approximately 15% to 0%, this will likely result in a strong upsurge in EV adoption.

Furthermore, as depicted in Figure 6b, if the price difference between an EV and ICE is zero, this leads to a much steeper increase in EV purchase likelihood in case of range increases than under other price levels. Thus, not only is the EV purchase likelihood higher in the case of a 0% price difference than under other levels, this dissimilarity will grow as the range of EV’s enhances.

**Figure 6a and 6b: EV Purchase Likelihood for various Price differences and Ranges.** Figure 6a shows a steep increase for a price decrease from 15% to 0% difference for a range of 750 km, which is not experienced for the other range levels. Figure 6b shows considerably steeper EV adoption increase for 0% price difference than other price levels. No differences exist between the HEV and EV purchase likelihood.

### 5.3 Other factors
Finally, respondents indicated other not-mentioned features which were of importance to them in such a purchase decision. The factor mentioned most often as ‘other’ proved to be the towing capacity (34% of the “other” category, 29 respondents). This is an interesting discovery, as EVs currently do not have any towing capacity at all, and only a limited number of HEVs are able to tow (ANWB 2013). Towing capacity is a key factor for Dutch respondents, as they need to be able to drive with e.g. caravans or horse trailers. This finding was supported by Interviewee 2, who believes the unavailable towing capacity of electric vehicles to be a barrier, albeit minor, in large scale adoption of EVs.
Besides this, residual value of the car was mentioned several times by our respondents as well. This corresponds to the consumer focus on Total Cost of Ownership when purchasing an (H)EV (Interviewee 2).

Finally, both Interviewees mentioned the appearance of the car to influence an (H)EV purchase decision. In our direct survey question, appearance was mentioned by 21% of the respondents, therefore also a modest factor in (H)EV adoption.

See Appendix VIII for detailed results of our direct survey question.
Discussion

Reflecting on the findings in relation to our research question as presented in the introductory chapter, we argue price and range to be the key factors with the largest effect on the adoption of (hybrid) electric vehicles in the Netherlands, followed by annual cost savings and fast charging times.

Practical Implications

Range is found to be vital in an (H)EV purchase consideration, consistent with the findings of e.g. Lieven et al. (2011) and Tate et al. (2008) and confirming our hypotheses. For EVs range is of an even slightly larger importance, most likely caused by the possibility of range extension through switching to the combustion engine of an HEV – an opportunity not present when driving an EV – thereby indicating a higher range anxiety experienced for the latter type of vehicle. As seen before, a range increase to approximately 200 km will raise (H)EV sales, where after further range increases until 500 km will not lead to adoption growth. When reflecting on these results, two groups can be distinguished. (H)EVs with a range up to 200 km are likely to be used as city cars and for shorter distances. This group is expected to consist of people owning an (H)EV as a second car in the family. The other distinct group requires vehicles to be able to drive long distances of 500 km and over, which includes (H)EV owners such as businessmen needing to visit several customers per day or families using the vehicle as the primary car in the family. Keeping in mind the current 50 to 150 km range of middle class (H)EVs, car and battery manufacturers should focus their efforts on developing batteries with a range of about 200 km. As drivers appear to be relatively indifferent between (H)EVs with 200 km and 500 km ranges, manufacturers should thereafter focus on extending ranges to values similar to ICE cars, being 500 km or more. Since lease drivers show to be more willing to adopt (H)EVs, lease companies will benefit most by offering (H)EVs with ranges of approximately 200 km.

Next, together with range, price appeared to be key in (H)EV adoption, thereby confirming the findings of Lieven et al. (2011) and our hypothesis. At present, HEVs and mainly EVs are still considerably more expensive than ICEs, which is clearly showing to be a barrier in large scale (H)EV adoption. As technology matures, prices will be driven down to levels close to ICE vehicles. Yet, as argued above, range should substantially increase at the same time to allow considerable surges in (H)EV sales. Since battery and price are inextricably bound, (H)EV manufacturers should aim to balance these two essential factors. If ranges increase, prices of (H)EVs with lower ranges are likely to drop, thereby making way for adoption in middle and lower class segments of the population. However, as range and price are still major barriers in large scale adoption, one should not expect considerable increases in (H)EVs before long. Moreover, drawing on the results of our interviews, (H)EV companies may want to focus on reselling second-hand (H)EVs. This can open a new market, as discounted (H)EVs may suit the
needs of families as a secondary car perfectly. On a final note, the technical lifespan of the battery should be taken into account. Repeated charging decreases the capacity of batteries, in turn lowering the range. Should this occur within a few years, frequent battery replacement is needed leading to considerable costs. Yet again, this may provide an opportunity for a second-hand battery market to open in the coming years.

The aforementioned price barrier is lowered by annual cost savings, which incorporates both fuel prices and tax benefits. Although of a moderate influence, these savings are positively related to (H)EV adoption, which is consistent with the findings of e.g. Chandra et al. (2008), Gallagher and Muehlegger (2010), Jenn et al. (2013), Bockarjova et al. (2013), McManus and Berman (2005) and Diamond (2009). Regarding tax benefits, these can substantially lower the price barrier of (H)EVs, as the large initial investment is mitigated by the subsequent lower costs of ownership. Therefore, governments should keep financial stimuli for electric driving in place, until prices of (H)EVs are lowered through the previously mentioned market forces. As argued in the interviews, lease drivers often opt for an HEV due to the fiscal benefits. However, these lease drivers often do not use the battery at all, but solely use the combustion engine of the car. Therefore, we recommend the Dutch government to review the lower fiscal surcharge for HEVs, and bring it down to ICE levels, thereby primarily stimulating full electric driving.

Contrary to the other factors, detour time does not confirm our hypothesis, and is therefore inconsistent with the study of Sierzchula et al (2014). Our study shows the questionable finding of a less sophisticated infrastructure – thus longer detour times – leading to higher (H)EV adoption. This result is possibly caused by a misunderstanding of respondents of the concept. Moreover, it may be the case that due to information overload, respondents ignored the detour time variable, causing the unrealistic findings.

Lastly, fast charging time appeared to be influential on (H)EV adoption, as opposed to the insignificant effect of regular charging time. This does confirm our hypotheses regarding fast charging time, yet the results for regular charging time do not meet our expectations, thereby being only partly consistent with the findings of Hidrue et al. (2011). The moderate effect of fast charging corroborates with the results of the interviews, where it was argued that charging infrastructure and times are satisfactory for the current (H)EV market, but may grow into a barrier if not developed adequately in the coming years. In countries with less sophisticated infrastructure than The Netherlands, this may already be a factor limiting the (H)EV adoption. Therefore, battery manufacturers, grid operators as well as national governments should focus on developing the fast charging infrastructure, being faster battery charging and increasing the number of charging points along major (high)ways. This will increase the mobility of (H)EV drivers, thereby likely leading to an increase in adoption. Moreover, grid operators should take timely actions to prevent charging infrastructure from becoming a barrier.
Possible Growth Scenarios
Based on our findings and historical car sales, a rough estimate can be made of future scenarios of (H)EV adoption numbers in The Netherlands (see Appendix III for assumptions). Table 11 displays the historical car sales, showing that the yearly growth rate has declined in the past three years. If the current vehicle features and external conditions remain similar, a yearly growth rate of about 50% and 30% may be expected for HEVs and EVs respectively.

<table>
<thead>
<tr>
<th>Year</th>
<th>Registered Vehicles</th>
<th>Absolute increase</th>
<th>% increase in registered vehicles to year before</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HEV</td>
<td>EV</td>
<td>HEV</td>
</tr>
<tr>
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<td>4,348</td>
<td>1,910</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>2014</td>
<td>36,937</td>
<td>6,825</td>
<td>12,425</td>
</tr>
<tr>
<td>2015</td>
<td>55,723</td>
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<td>18,786</td>
</tr>
<tr>
<td>2016</td>
<td>84,141</td>
<td>11,384</td>
<td>28,418</td>
</tr>
</tbody>
</table>

Table 11: Historical and Future (H)EV Sales (RVO 2015)

As the (H)EV industry develops, governmental incentives change and charging infrastructure is upgraded, and different sales number and yearly growth rates may be expected. Below, three possible scenarios are provided. However, one should keep in mind that intended purchase deviates from versus realized purchases, and therefore these numbers should be regarded with caution. More research is needed to be able to accurately predict (H)EV sales and market shares.

<table>
<thead>
<tr>
<th>Range</th>
<th>Price</th>
<th>Annual cost savings</th>
<th>Fast charging time</th>
<th>Expected Yearly Sales numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Worst case</td>
</tr>
<tr>
<td></td>
<td>HEV</td>
<td>EV</td>
<td>HEV</td>
<td>EV</td>
</tr>
<tr>
<td>250 km</td>
<td>60%</td>
<td>40%</td>
<td>25 min</td>
<td>20,622</td>
</tr>
<tr>
<td>250 km</td>
<td>30%</td>
<td>40%</td>
<td>20 min</td>
<td>25,105</td>
</tr>
<tr>
<td>500 km</td>
<td>45%</td>
<td>15%</td>
<td>15 min</td>
<td>50,113</td>
</tr>
</tbody>
</table>

Table 12: Scenario Calculations

Theoretical Implications
Our study is among the first to include both HEVs and EVs in the analysis. However, as can be seen from the various results, no distinct difference in the purchase likelihood under varying trends of our incorporated predictive between the two types of vehicles is present. However, as new variables are included in a study, differences between the two vehicles may arise, and therefore HEVs and EVs should continue to be separated in future studies. Besides this, a distinction between regular charging time and fast charging time should remain to be made in future studies, as contrary to our expectations and previous studies, charging time has proven to

1 Based on sales until 31 May 2015
not be a significant factor in (H)EV purchase likelihood, while fast charging time is. Finally, as extensively discussed before, detour times do not show a plausible sign in the regression models. This result may be due to misunderstanding of the concept by the respondents, which can be solved in a next study by more thoroughly describing each factor. Besides, this contradictory outcome may be a result of methodological shortcomings, as there is reason to believe that respondents did not take into account detour time levels in the fixed scenarios at all, but solely focused on the other factors. Ignorance of detour time (as well as possible other factors) may be caused either by the triviality of the factor to respondents, or by an overload of information leading to a focus on the few most important factors (Orme 2012).

Limitations and Future Research

Although our results are stable across different tests, the study is subject to various limitations. Firstly, both mean values for the constructs environmentalism and interest in electric driving are above average (>0). This could limit our results, as respondents with greater interest in electric driving and more attention for the environment will have a greater tendency towards (H)EV purchase likelihood than lower scoring respondents. These higher mean values can have two possible causes. Either the study is subject to a biased sample, meaning the sample has particularly higher interests in electric driving in contrast to the population. Another plausible explanation may lie in a general increase in environmental consciousness and interest in electric driving, due to rising awareness stimulated by the government and campaigns. This would imply that the characteristics of the sample are similar to those of the population. Replicating the study using a larger and more varied sample size will provide closure on this issue.

The scope of our research is limited to the specific set of our six variables which were uncovered by previous literature, and hence our study does not, and cannot, intend to cover the full range of influencing factors. Future studies may wish to include our incorporated variables as well as a number of variables revealed in the findings of this study. Examples of such factors are towing capacity, appearance of the car and more comprehensive factors regarding Total Cost of Ownership. Our results showed towing capacity to be mentioned considerably often as being important by respondents. If EVs with towing capacity will be introduced, the launch of these vehicles may lead previously uninterested consumer segments to become open for purchase after all. Furthermore, Dutch insurance companies are currently offering special insurances for (H)EVs, with superior conditions and premiums. Possibly, these specific insurances serve as a (H)EV adoption stimulator as well. Besides this, we only incorporated national charging infrastructure in our analysis. However, especially for private drivers international charging possibilities and/or fast charging times may of considerable importance, since these factors either allow or limit them in using an (H)EV for going on holidays abroad. Furthermore, a more all-encompassing factor of Total Cost of Ownership can be included. For instance, our survey
showed residual value to be mentioned several times as an attribute to consider. It may be the case that some respondents subconsciously took this factor into account in either the price or annual cost savings variable. Future studies may wish to include the variable Total Cost of Ownership, thereby clearly specifying all costs included in this factor, such as purchase price, depreciation, residual value, electricity prices, tax benefits etc. Moreover, research may wish to focus on a possible relationship between ownership of solar panels and the purchase of an (H)EV, as these panels lead to reduced charging costs. The reduced charging costs may be another stimulator of (H)EV adoption as well.

Finally, future research may wish to administer a choice-based conjoint analysis, thereby eliciting the specific trade-off between HEVs and EVs under various scenarios. Also, a simulation analysis may be used based on the stated preferences of our respondents, allowing for modeling, analyzing and predicting future HEV and EV market shares.
Conclusion

In this paper we present the results of a survey based experiment with 307 respondents and thereby elicit the most important factors in the adoption of HEVs and EVs. In order to do so, a conjoint analysis is used allowing us to identify subconscious preferences of consumers in (H)EV adoption, and bring forth any variances between different groups of drivers. We found one significant difference in mean scores of the environmentalism and interest in electric driving constructs between private and lease drivers, namely a significantly higher interest in electric driving of lease drivers.

Respondents were asked to rate their (H)EV purchase likelihood under varying levels of six (H)EV features: Price difference between an (H)EV and ICE, annual cost savings due to driving an (H)EV instead of an ICE (including fuel cost savings and tax reductions), battery range of an (H)EV, charging time (at home or at work), fast charging time (at dedicated stations along the highways) and lastly the average detour time (representing the saturation of charging stations across the country).

The findings show that price difference, range and annual cost savings are the three most influential factors in the purchase consideration of an (H)EV, as shown by the utility values as well as the significant (and large) coefficients in our regression models. This outcome is backed in the interviews, where it was argued that range and price levels of hybrid and full electric vehicles are the main factors limiting large scale (H)EV adoption. Range proves to be more important for EV adoption than for HEV adoption, which is likely due to increased range anxiety when driving EV's. For HEV’s, price difference is the most important factor, as the total range can be extended by simply switching to using the combustion engine.

Furthermore, lease drivers show a significantly higher interest in electric driving, which is reflected in the consistently higher purchase intentions of hybrid and full electric vehicles among lease drivers compared to private drivers. This difference is most likely caused by the tax advantages incurred by lease drivers, such as the lower fiscal surcharge regulation. Our interviewees confirmed that the majority of the (H)EV’s are sold to lease drivers, who’s main motivation for the purchase is of monetary nature.

It can be concluded that an increase in range to approximately 200 km will result in higher (H)EV adoption. As the current battery range of an hybrid and full electric vehicle lies around 50 to 150 km for the middle class cars, (H)EV adoption is expected to continue to rise slightly. Further enhancements in range are not expected to yield substantial increases in (H)EV adoption, until the threshold of an approximately 500 km range is reached. Thereafter, one can expect considerable increases in (H)EV sales. The consequences of range expansions are intensified by price differences. In case of a lower price difference between (H)EV’s and ICE cars,
the adoption of hybrid and full electric vehicles will be steeper when range increases. Similarly, when ranges of (H)EV's are high (>750 km), vast increases in (H)EV sales will occur compared to situations with lower ranges. However, price and range are strongly interconnected, as the major component of (H)EV price is the battery. Thus, with increasing range one cannot expect price reductions simultaneously, and vice versa.

Moreover, fast charging time has a moderate influence, whereas charging time and detour time do not show to be of considerable importance in (H)EV adoption. Nonetheless, in the interviews it was stated that the charging infrastructure – which incorporates all three factors – can turn into a barrier if (H)EV adoption becomes widespread but nationwide charging infrastructure does not evolve suitably. One of the main practical purposes of this study is clearly highlighted by this statement, as grid operators should prepare their infrastructure to be able to support extensive (H)EV adoption.

Grid operators can anticipate on even increases in (H)EV numbers, with a slightly higher amount of hybrid vehicles compared to full electric vehicles. As the most important factors in the adoption are price and range, grid operators should mainly watch the development of these features in order to prepare the grid for large increases in (hybrid) electric vehicle amounts. Sizeable increases in (H)EV numbers can be expected once both hybrid and electric vehicles reach price levels comparable to or deviating at most 10-15% of similar ICE cars, and driving ranges are similar to the ranges of ICE cars at the same time.
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## Appendices

### Appendix I: Past and current incentives for driving EV’s as implemented by the Dutch government

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Initial incentive</th>
<th>Adjusted incentive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiscal surcharge (&quot;Bijtelling&quot;)</td>
<td>0% for cars with CO2 emission below 50 gr/km and first license plate given before 2014</td>
<td>For all first license plates given from 2014&lt;br&gt;○ 4% for cars with a CO2 emission of 0 gr/km&lt;br&gt;○ 7% for cars with a CO2 emission above 0 gr/km but below 50 gr/km&lt;br&gt;○ 14% for cars with a CO2 emission above 50 gr/km but below 85 gr/km&lt;br&gt;○ 20% for cars with a CO2 emission above 85% but below 111 gr/km&lt;br&gt;○ 25% for all other cars</td>
</tr>
<tr>
<td>Motor vehicle tax (&quot;MRT&quot;)</td>
<td>Exemption from motor vehicle tax for environmental friendly cars up until 2014.&lt;br&gt;Cars with a CO2 emission below 50 gr/km are exempted until 1 January 2016.</td>
<td>From 2014 onwards motor vehicle tax is calculated based on weight. For electric vehicles, 125kg is subtracted from the total vehicle weight. This will also count for cars with a CO2 emission below 50 gr/km after 1 January 2016. From 2016 onwards, the motor vehicle tax for hybrid electric vehicles is raised to 50% of ICE cars.</td>
</tr>
<tr>
<td>Taxation of cars and motorcycles (&quot;BPM&quot;)</td>
<td>Exemption of taxation when the vehicle has a CO2 emission of 0 gr/km.</td>
<td>Source: Belastingdienst (2014), Rijksoverheid (2014)</td>
</tr>
</tbody>
</table>
Appendix II: Survey
This survey has been conducted in Dutch, as to enable any Dutch citizen to complete the survey.

1. Bent u momenteel in het bezit van een auto, of heeft u eerder een auto gehad?
   [ ] Ja  → Naar vraag 2
   [ ] Nee → Naar vraag 3

2. Is of was dit een hybride of volledig elektrische auto?
   [ ] Hybride
   [ ] Elektrisch
   [ ] Geen van beide

3. Wanneer bent u van plan een nieuwe auto aan te kopen?
   [ ] Binnen nu 2 jaar
   [ ] Over 2 tot 5 jaar
   [ ] Over meer dan 5 jaar
   [ ] Weet ik niet
   [ ] Ik ben niet van plan een auto te kopen

4. Stel dat u een nieuwe auto zou kopen, wat is dan het voornaamste doel van deze nieuwe auto?
   [ ] Prive gebruik  → Naar vraag 5
   [ ] Zakelijk gebruik (lease)  → Naar vraag 6

5. Wat is de functie van de nieuwe auto in uw huishouden?
   [ ] Eerste auto
   [ ] Tweede auto
   [ ] Anders
      Namelijk: ....

6. Hieronder volgen een aantal uitspraken. In hoeverre bent u het eens met deze uitspraken?

   Mensen moeten hun levensstijl veranderen om het milieu te beschermen

   Neutraal
   Helemaal niet mee eens     [ ] [ ] [ ] [ ] [ ] Helemaal mee eens

   Klimaatverandering is een ernstig probleem

   Neutraal
   Helemaal niet mee eens     [ ] [ ] [ ] [ ] [ ] Helemaal mee eens

   Klimaatverandering is een gevolg van menselijke handelingen

   Neutraal
   Helemaal niet mee eens     [ ] [ ] [ ] [ ] [ ] Helemaal mee eens
Milieuproblemen waar de mensheid mee wordt geconfronteerd zijn sterk overdreven

Helemaal niet mee eens  []  []  []  []  []  Helemaal mee eens

Ik ben geïnteresseerd in het concept Elektrisch Rijden

Neutraal

Helemaal niet mee eens  []  []  []  []  []  Helemaal mee eens

7. Stel dat u een auto zou willen kopen. Neem de auto in gedachten waarvan het zeer waarschijnlijk is dat dit de auto is die u zal kiezen.

Welke auto heeft u in gedachten genomen?
* Als u het exacte type niet weet, voldoet een omschrijving of merk ook.

Purchase Likelihood (example scenario)

8. De eigenschappen van de hybride én elektrische variant van uw voorkeursauto zijn:

<table>
<thead>
<tr>
<th>Eigenschap</th>
<th>Waarde</th>
<th>Omschrijving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aanschafprijs</td>
<td>45% duurder dan een zelfde benzine of diesel auto</td>
<td>Het verschil in de aanschafprijs van de hybride/elektrische auto in vergelijking met een zelfde benzine of diesel auto</td>
</tr>
<tr>
<td>Jaarlijkse kosten</td>
<td>25% besparing per jaar t.o.v. een zelfde benzine of diesel auto</td>
<td>Het verschil in jaarlijkse kosten van de hybride/elektrische auto in vergelijking met een zelfde benzine of diesel auto</td>
</tr>
<tr>
<td>Rijbereik</td>
<td>500 kilometer</td>
<td>Het aantal kilometers dat men in de hybride/elektrische auto met een volledig opgeladen batterij kan rijden, in normale omstandigheden</td>
</tr>
<tr>
<td>Laadtijd</td>
<td>1 uur</td>
<td>De laadtijd die benodigd is om de batterij van de hybride/elektrische auto volledig op te laden, thuis of op het werk</td>
</tr>
<tr>
<td>Snellaad tijd</td>
<td>20 minuten</td>
<td>De tijd die benodigd is om de hybride/elektrische auto volledig op te laden, bij speciale stations langs de snelweg</td>
</tr>
<tr>
<td>Omrijtijd</td>
<td>20 minuten</td>
<td>De extra tijd die men om moet rijden met de hybride/elektrische auto om een laadpunt te bereiken</td>
</tr>
</tbody>
</table>

Hoe waarschijnlijk is het dat u de volgende auto’s koopt in dit scenario? Beoordeel deze overweging apart voor beide typen auto’s.

<table>
<thead>
<tr>
<th></th>
<th>Helemaal niet waarschijnlijk</th>
<th>Zeer waarschijnlijk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybride auto</td>
<td>[] [] [] [] [] []</td>
<td>[] [] [] [] []</td>
</tr>
<tr>
<td>Volledig elektrische auto</td>
<td>[] [] [] [] [] []</td>
<td>[] [] [] [] []</td>
</tr>
</tbody>
</table>
23. Stel dat u een hybride of volledig elektrische auto zou aanschaffen. Welke factoren zijn voor u het meest van belang?

- Aanschafprijs
- Acceleratietijd
- Gemiddelde omrijtijd om een laadpaal te bereiken
- Hoeveelheid besparing op benzine/diesel kosten
- Jaarlijks belastingvoordeel
- Laadtijd (thuis of op werk)
- Milieuvriendelijkheid van de auto
- Rijbereik
- Snellaadtijd
- Uitstraling/imago van de auto
- Anders, namelijk...

24. Geslacht:
- Vrouw
- Man

25. Leeftijd:
- <21
- 21 - 30 jaar
- 31 - 40 jaar
- 41 - 50 jaar
- 51 - 60 jaar
- > 61 jaar

26. Wat is uw hoogst genoten opleiding?
- Basisonderwijs
- Praktijkonderwijs
- VMBO/MAVO
- HAVO
- VWO
- MBO
- HBO
- WO
- Anders, namelijk...

27. In wat voor een omgeving woont u?
- Stad
- Voorwijk
- Dorp
- Platteland
Appendix III: Assumptions

Attribute levels (page 21)
Costs average ICE car: €25,000
Costs average (H)EV: €40,000
Average CO2 emission ICE car: 109 gram/km (Duurzaambedrijfsleven 2014)
Current average battery range EV: 150 km
Current average battery range HEV: 50 km
Number of charging stations in the Netherlands: 5792 (RVO 2015)
Number of (public and semi-public) fast charging stations in the Netherlands: 295 (RVO 2015)
Fuel costs as per 31 March 2015: €1.69/L (Euro95) (brandstofprijzen.info)

Scenario Calculations (page 43)
Number of HEV sales in 2014: 12,425 (RVO 2015)
Number of EV sales in 2014: 2,664 (RVO 2015)
Best case scenario: 80% of consumers realize purchase
Middle case scenario: 50% of consumers realize purchase
Worst case scenario: 30% of consumers realize purchase
Average education level: 6 (MBO) Dutch average: lower education 32.7%, secondary education 39.3%, higher education 26.8%, other 1.2% (Source: cbs.nl)
Car type level: 3 (ICE) Dutch average: ICE 99.4%, Hybrid 0.5%, Full electric 0.1% (Source: rvo.nl)
Age: 4.5 (40-50 years old). Dutch average: 21-40 years 25%, 40-60 years 29%, 60+ years 24%. (Source: cbs.nl, metro.nl)

Calculations are based on 2014 sales numbers in relation to the predicted purchase likelihood according to our regression model under current factor levels for HEVs and EVs.
### Appendix IV: Correlations

<table>
<thead>
<tr>
<th>Control Variables</th>
<th>Predictive Variables</th>
<th>Price Difference</th>
<th>Annual Cost Savings</th>
<th>Range</th>
<th>Charging Time</th>
<th>Fast Charging Time</th>
<th>Detour Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car type</td>
<td>Correlation 1.000</td>
<td>0.347</td>
<td>-0.074</td>
<td>0.479</td>
<td>-0.067</td>
<td>0.400</td>
<td></td>
</tr>
<tr>
<td>Next car purchase</td>
<td>df 3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td></td>
</tr>
<tr>
<td>Car use (Private/Lease)</td>
<td>Correlation 0.347</td>
<td>1.000</td>
<td>0.162</td>
<td>0.070</td>
<td>-0.081</td>
<td>-0.549</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>df 3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Correlation -0.074</td>
<td>0.162</td>
<td>1.000</td>
<td>0.070</td>
<td>0.000</td>
<td>-0.464</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>df 3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td></td>
</tr>
<tr>
<td>Living area</td>
<td>Correlation 0.479</td>
<td>-0.081</td>
<td>0.070</td>
<td>1.000</td>
<td>-0.129</td>
<td>-0.166</td>
<td></td>
</tr>
<tr>
<td>Environmentalism</td>
<td>df 3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td></td>
</tr>
<tr>
<td>Interest Electric Driving</td>
<td>Correlation -0.067</td>
<td>-0.549</td>
<td>-0.464</td>
<td>-0.129</td>
<td>1.000</td>
<td>0.233</td>
<td></td>
</tr>
<tr>
<td></td>
<td>df 3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td>3964</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix V: Utility estimation

<table>
<thead>
<tr>
<th>Utilities for HEV</th>
<th>Utility Estimate</th>
<th>Std. Error</th>
<th>β Coefficient</th>
<th>Averaged Importance Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price difference</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0% higher</td>
<td>-0.470</td>
<td>0.099</td>
<td>-0.470</td>
<td>42.09</td>
</tr>
<tr>
<td>15% higher</td>
<td>-0.940</td>
<td>0.197</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30% higher</td>
<td>-1.409</td>
<td>0.296</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45% higher</td>
<td>-1.879</td>
<td>0.394</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60% higher</td>
<td>-2.349</td>
<td>0.493</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual costs savings</strong></td>
<td></td>
<td></td>
<td>0.134</td>
<td>11.98</td>
</tr>
<tr>
<td>5%</td>
<td>0.134</td>
<td>0.086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15%</td>
<td>0.267</td>
<td>0.172</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>0.401</td>
<td>0.258</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40%</td>
<td>0.535</td>
<td>0.344</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td>0.669</td>
<td>0.430</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td></td>
<td></td>
<td>0.002</td>
<td>32.01</td>
</tr>
<tr>
<td>50 km</td>
<td>0.102</td>
<td>0.018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150 km</td>
<td>0.306</td>
<td>0.053</td>
<td></td>
<td></td>
</tr>
<tr>
<td>250 km</td>
<td>0.510</td>
<td>0.089</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 km</td>
<td>1.021</td>
<td>0.178</td>
<td></td>
<td></td>
</tr>
<tr>
<td>750 km</td>
<td>1.531</td>
<td>0.266</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Charging time</strong></td>
<td></td>
<td></td>
<td>-0.019</td>
<td>2.92</td>
</tr>
<tr>
<td>1 hour</td>
<td>-0.019</td>
<td>0.047</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 hours</td>
<td>-0.037</td>
<td>0.094</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 hours</td>
<td>-0.075</td>
<td>0.188</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 hours</td>
<td>-0.112</td>
<td>0.283</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 hours</td>
<td>-0.150</td>
<td>0.377</td>
<td></td>
<td></td>
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Appendix VI: Linear regression assumptions HEV model

Histogram
Dependent Variable: HEV Purchase Likelihood

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: HEV Purchase Likelihood
White's test for HEV Model

\[ LM = R^2 \times n \]

\[ R^2 = 0.199, \quad n = 4605 \]

\[ LM = 0.199 \times 4605 = 916.4 \]

\[ \chi^2_{n=4605} = 4831 \]

Since \( LM < \chi^2 \), the null hypothesis is not rejected and heteroscedasticity cannot be confirmed.
Appendix VII: Linear regression assumptions EV model
White's test for EV Model

\[ LM = R^2 \cdot n \]

\[ R^2 = 0.285, n = 4605 \]

\[ LM = 0.285 \cdot 4605 = 1312.4 \]

\[ \chi^2_{n=4605} = 4831 \]

Since \( LM < \chi^2 \), the null hypothesis is not rejected and heteroscedasticity cannot be confirmed.
Appendix VIII: Importance of features

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<td>Environmental friendliness</td>
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<td>Other</td>
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</table>

![Importance of features in (H)EV's](image-url)
Appendix IX: HEV purchase likelihood graphs for varying factors
Appendix X: EV purchase likelihood graphs for varying factors