Travail de fin d'études: "Potential use of electric vehicle in Wallonia"

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POTENTIAL USE OF ELECTRIC VEHICLE IN WALLONIA

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in Sustainable Energy Management

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ABSTRACT

The environment problems are worldwide concerns nowadays. The air and noise pollution, the use of fossil fuels in transport etc. are mainly some of the things that affect the environment in the World. To reduce those environmental problems, governments encourage the persons to use zero carbon vehicles like EVs (electric vehicles) for their daily travel behavior for example from home to work, study or for their leisure. In Belgium there are some EVs but the purchasing and use of them is still low because of especially their price, battery limit (recharging) and small travelled distance.

In this study used a questionnaire survey where the respondents that lives in Wallonia gave their thoughts and opinions about the use of EVs. In each province of Wallonia, 4 communes were chosen randomly. After collecting the data, a database have been created for treatments and analysis in R software where descriptive statistics, linear regression and logit - probit analysis are assessed to see the likelihood to use an EV and predict the probabilities of using an EV in Wallonia.

The analysis show that the preference of an EV over an oil (petrol/diesel) vehicle, depends on different factors. The purchase of the EV depends on the user consideration, the near future buyers (early adopter), the use of EV to go to work, the environmentally aware persons but at a lower level, depends again on having already an experience of an electric or a hybrid vehicle, the level of education and the household income.

Even though some respondents wants to buy an EV, they are still limited by the price, the battery life, the shorter distance to travel and most importantly the production of electricity for EV. If the production of electricity is low-carbon emissions or no CO2 emissions at all like renewable sources and new technologies that improve the battery life, the shorter distance, and the stimulation of the government like subsidies for EV purchase the EV can be successful in Wallonia especially in the urban areas.

<u>Keywords</u>: *Electric vehicle potential use, early adopters, environmentally aware, transition, urban commuting, air pollution reduction, Wallonia*.

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List of abbreviations

ANOVA: Analysis of variance

BEV / BEVs: Battery Electric Vehicle (s)

CARB: California Air Resources Board

CEO: Chief Executive Officer

CI: Confidence Interval

CO2: Carbon dioxide

D.C.: District of Columbia

EI: Environmental Impact

EPA: Environmental protection agency

EV / EVs: Electric vehicle (s)

EVI: Electric Vehicle Initiative

EVSE: Electric vehicle service equipment

FCEV / FCEVs: Fuel cell-electric vehicle (s)

GHG: Greenhouse gas

GM: General Motors

GWP: Global Warming Potential

HEV / HEVs: Hybrid electric vehicle (s)

ICE: Internal combustion engine

ICEV: Internal combustion engine vehicle

IEA: International Energy Agency

KWh: Kilowatt - hour

LCA: Life cycle analysis

METI: Ministry of Economy, Trade and Industry

NEDD: New European Driving Cycle

NGVP: Network Generation Vehicle Plan

OEM / OEMs: Original equipment manufacturer (s)

PEM: Precise electrochemical machining

PHEV / PHEVs: Plug-in hybrid electric vehicle (s)

R&D: Research and development

RE: Renewable Energy

REEV / REEVs: Range extended electric vehicle (s)

SUV: Sport utility vehicle

TTC: Toutes charges comprises

TTW: Tank-To-Wheel

U.K.: United Kingdom

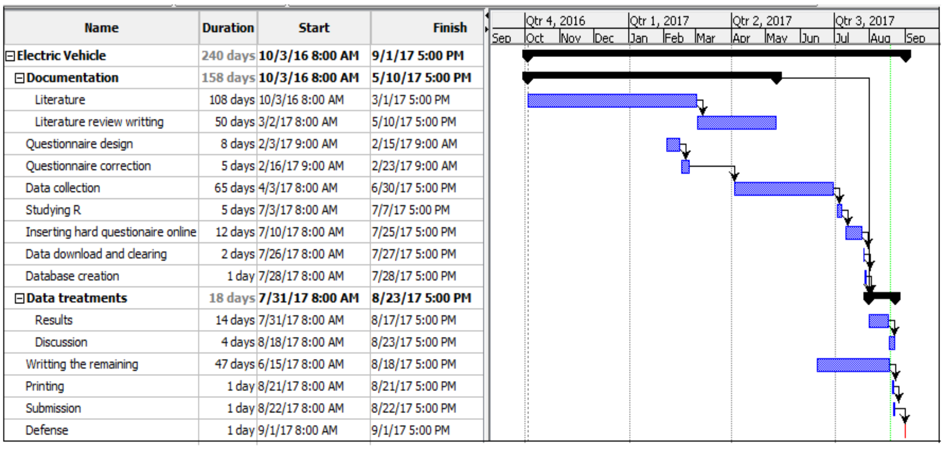
U.S. / U.S.A.: United States / United States of America

VAT: Value added tax

ZEV: Zero Emission Vehicle

I. INTRODUCTION

The electric vehicle is a vehicle that operates with one or more electric motor for propulsion. Electricity is used to fuel the battery of EV and the energy is stored in the battery but its capacity is still limited. More research are done on EVs among them are the EV technologies in order to improve the battery capacity, the EV range, the capacity to travel longer distances and so on. Furthermore, the use of EV especially in urban areas contributes to lower pollution like CO2 emissions, noise etc. and can be a better transport alternative in cities. This research focuses on the use of an EV in Wallonia. The persons living in Wallonia are questioned about how they see the use of an EV in their daily travel behavior. The study timeline and procedures used for this research are presented as follows:



Name	Duration	Start	Finish
Electric Vehicle	240 days	**10/3/16 8:00 AM**	**9/1/17 5:00 PM**
Documentation	158 days	**10/3/16 8:00 AM**	**5/10/17 5:00 PM**
Literature	108 days	10/3/16 8:00 AM	3/1/17 5:00 PM
Literature review writting	50 days	3/2/17 8:00 AM	5/10/17 5:00 PM
Questionnaire design	8 days	2/3/17 9:00 AM	2/15/17 9:00 AM
Questionnaire correction	5 days	2/16/17 9:00 AM	2/23/17 9:00 AM
Data collection	65 days	4/3/17 8:00 AM	6/30/17 5:00 PM
Studying R	5 days	7/3/17 8:00 AM	7/7/17 5:00 PM
Inserting hard questionaire online	12 days	7/10/17 8:00 AM	7/25/17 5:00 PM
Data download and clearing	2 days	7/26/17 8:00 AM	7/27/17 5:00 PM
Database creation	1 day	7/28/17 8:00 AM	7/28/17 5:00 PM
Data treatments	18 days	**7/31/17 8:00 AM**	**8/23/17 5:00 PM**
Results	14 days	7/31/17 8:00 AM	8/17/17 5:00 PM
Discussion	4 days	8/18/17 8:00 AM	8/23/17 5:00 PM
Writting the remaining	47 days	6/15/17 8:00 AM	8/18/17 5:00 PM
Printing	1 day	8/21/17 8:00 AM	8/21/17 5:00 PM
Submission	1 day	8/22/17 8:00 AM	8/22/17 5:00 PM
Defense	1 day	9/1/17 8:00 AM	9/1/17 5:00 PM

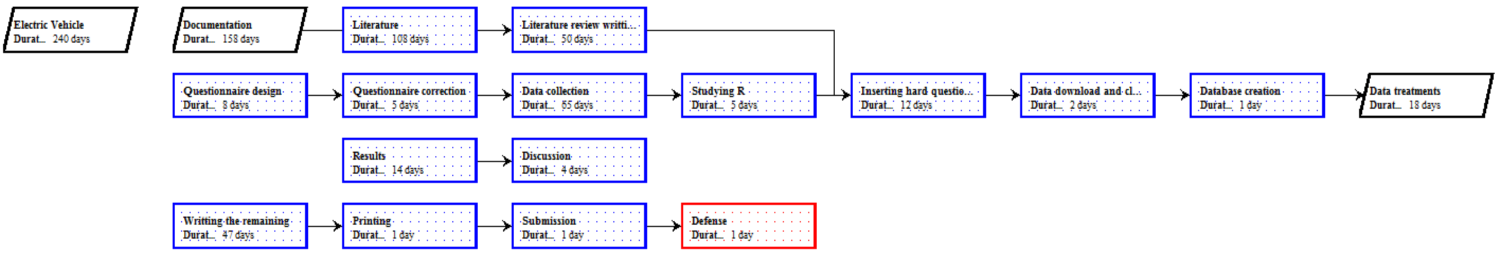


Figure 1: Timeline of tasks for the study

1.2. The research problem

The transport domain is among the things that affect the environment especially because of the use of fossil fuels. Analyzing the views and opinions of the Wallonia residents about the utilization of an EV for their commuting behavior is important to study the possibilities of EV use. Driving an EV especially in urban areas can be one of the solution in order to reduce local air pollution or GHG. The people will benefit a good environment with CO2 reduced, and will reduce the cost of fuel as well as of maintenance if they use an EV most importantly with a decarbonized electricity production.

1.3. The purpose and objectives of the study

More studies about EVs are done. Many has focused on the EV market potential, the EV technologies, decarbonizing transports, etc. in different countries. This study focused on the user's views about EVs. The purpose is to study the potential use of an EV in Wallonia. The contribution of this research to existing studies is that based on the process of data collection which is a questionnaire survey where the respondents give their feelings, views and opinions about the use of electric cars, we could see the variables that can influence the purchase of EV and the preference of EV over traditional cars (like ICEVs) in Wallonia. Hence, the prediction of the probabilities to purchase or prefer an EV is made. Besides, the main objectives of this study are:

- Predicting the purchase and use of EV in Wallonia;
- Possibilities of the EV market in predicting the probabilities to prefer EV;
- Assess the constraints due to the use an EV.

To know the probabilities of purchasing an EV is important in order to know the possibilities on the EV market and know if the population could or could not transit to EVs. Then we evaluate the constraints encountered for people who has an experience with EVs or hybrid vehicles or even who want to adopt and use electric cars especially in urban areas for their travel behavior. Depending on different factors that are early adopters, environmentally aware, transitioning with only benefit, urban liveability etc. we will see the probabilities to purchase or prefer an EV.

1.4. Scope of the study

This research aims to give ideas and opinions of peoples about EVs (only all-electric vehicles) not hybrid (plug-in hybrid), nor electric bikes. Then, the research estimates the potential use of EV in Wallonia. For this research, we conducted a questionnaire asking randomly the persons who live in Wallonia in Belgium. The chosen communes of Wallonia to collect the data as well as the methodologies used are explained in chapter 3. The persons who contributed in responding to questionnaire mainly with our physical presence on the Wallonia chosen commune responded seriously and could ask questions where they are doubting. The limitation was that some of them did not have time to finish the whole questions, so we had to fix another appointment to come back and pick the answered questionnaire. Sometimes they do not finish and finally were removed because we only used questionnaires completed in full.

1.5. The research structure and principal findings

This study is composed of six chapters. The first chapter introduces the work and explain in summary. The second chapter is about the review of literature about EVs globally and in Belgium last. The methodologies used are described in chapter three. The results are presented in chapter five. Then chapter six discusses about the results obtained. In fact it describes the sample, outlines the relationship between dependent and independent variable for the linear regression, predicts the probabilities of purchasing an EV in simple and multiple linear regression and last it explains the logit and probit models.

The research main findings show the relation between purchasing an EV and the degree variable, the environmental aware, the persons who consider to use an EV, who want to use it in the near future and who use or want to use it for work. The preference of an EV using a logit or probit model show positively or negatively the chance to prefer an EV with seven influencing variables which are the degree, professional status, experience with the use of an electric bike, the environment, the limit in price of EV (high cost of EV) and the limit in distance to travel with an EV.

II. LITERATURE REVIEW

Through literature, this research talks about a brief history of EV worldwide, the development of EV, the climate change, environment and early adopters, and then the EV market. Next it explains how EV is used or encouraged globally today worldwide first, in Belgium second and in Wallonia our case study. The literature ends with the research question and hypotheses.

2.1. The history of electric vehicles (EV)

The first electric vehicle started in the early 19th century especially in the United States (according to https://energy.gov). In this early part of the century (in the 1800's), the conception of a battery-powered vehicle and some small-scale electric vehicles have been created by innovators in Hungary, the Netherlands and the United States. The same time, in the commencement of 1830 (1832-1839), a Scottish inventor Robert Anderson created the first crude electric carriage which was powered by a non-rechargeable primary cells. In the United States, it was Thomas Davenport who invented an electric vehicle in 1834-1835 and he was the first EV practice. In 1859 a French physicist Gaston Planté invented the rechargeable lead-acid storage battery. This storage battery's ability to supply current has been improved by his compatriot Camille Faure in 1881 and he developed the basic lead-acid vehicles' battery. Next in Europe, in 1884 an Englishman Thomas Parker built the practical electric car.

The electric vehicles succeeded and during 1890's an electric car was a vehicle of choice and might even be charged at home. In Iowa, the United States, William Morrison of Des Moines constructed the first effective electric car. Succeeding in Chicago, different electric vehicle makes and models are revealed. In 1897 the first electric taxis knocked out the New York's streets. Next in Connecticut, the Pope Manufacturing Company became the first important American electric vehicle constructor. In 1899, Camille Jenatzy from Verviers Belgium was the first to make 100 km per hour with an EV. Then, Henry Pieper created the petroleo electric autos which were the first cars with thermal electric motorization.

Over history of electric vehicles construction, the persons found interesting that the electricity would run vehicles in the future. It comes then where they want to build the long-lasting and powerful battery. The latter has been created by Thomas Alva Edison in 1899, this was an alkaline batteries but even though he developed them, he finally renounced his pursuit a ten years later (www.pbs.org). The utilization of electric vehicles continued blossoming in the 1900. For example in the United States the 28% of cars were electric-powered and thus the electric vehicles were about one-third of all vehicles perceived in New York City, Chicago and Boston. In 1908 the automobile constructor Henry Ford presented the mass-produced and gasoline-powered model T (www.pbs.org), which have had a deep result on the United States automobile market. Moreover, the Herstal Auto Mixte firm from Belgium produced the vehicles between 1905 and 1912. The same year, the production of electric cars peaked and new standards were set by the G.M. (General Motors), the Detroit Electric United States. The inventor Charles Kettering provided the first concrete electric car starter in making a gasoline powered cars more appealing to users by removing the unmanageable hand level starter and eventually helped cover the way for the downfall of electric vehicle.

Due to some factors such as cheapen gasoline, the wish of travelling longer distance, the deficiency of electricity, the electric vehicle stopped being a feasible business product throughout the 1920s. The years between 1930s and 1960s were esteemed as the dead-years of the EV. Subsequently the use of fossil fuel increased but lately in 1966, the governments for example the Congress in the United States started recommending the usage of electric vehicles in order to reduce air pollution especially in transports. At that time there were a Gallup poll which revealed that 33 millions of American were appealed in electric vehicles (www.pbs.org).

During the 1970s, the price of oil (fossil fuel) increased because of the oil crises that happened especially in 1973 climaxing with the Arab Oil Embargo. Therefore from both consumers and producers a rising environmental organization ensued in restarted concerns in EV. Thereafter Victor Wouk, the so called "Godfather of the hybrid" constructed the first full-powered, full-size hybrid vehicle in 1972. The EV Symposium in Washington D.C. made its unveiling in

1974 which was a Vanguard-Sebring's CitiCar. It had a speed of 30 mph and a distance of 40 miles. Thru 1976 the Congress approved the measure on Electric and Hybrid Vehicle Research, Development and Demonstration. Later in 1977-1978 G.M. spent $ 20 million on R&D of EV Subsequently the CEO of G.M. Roger Smith approved to finance the research efforts to build a practical consumer EV within 1988. Throughout 1990 the Zero Emission Vehicle (ZEV) Mandate was conceded by California. It was entailing 2% of the state's vehicles to have no emissions by 1988 and 10% by 2003 but the act have been faded over ensuing decade to lower the amount of pure ZEVs it expected. The EV1 was also made in this year (1990) for lease which was quiet and faster than one of 30 mph.

Over the years, the Prius of Toyota was revealed during 1997. It was the first commercially mass-produced and marketed hybrid car in Japan (according to www.pbs.org) and closely 18,000 items were wholesaled through the first year of manufacture. Between 1997 and 2000 a few thousands of all-EV (such as Honda's EV Plus, G.M.'s EV1, Ford's Ranger pickup EV, Nissan's Altra EV, Chevy's S-10 EV, and Toyota RAV4 EV) were manufactured by big auto constructors, but mainly of them were accessible merely for rent. By the late 1990s and early 2000s, the main carmakers' progressed all-electric manufacture plans were ceased due to pressure from carmakers and oil industry.

Thru 2002 DaimlerChrysler and G.M. litigated the California Air Resources Board (CARB) which revoked the ZEV mandate on 1990 and the Bush Administration joined that suit. The G.M. stopped renewing leases of its EV1 autos because it couldn't supply repair parts and retrieved the vehicles by the end of 2004. By 2005, the G.M. spokesman Dave Barthmuss said that the EV1s were to be recycled in the film "who killed the electric car".

Afterwards in 2006 came the reality on the environment and climate change. The World needs a clean and green EV again so the EV is concluded to be a better choice in transport, especially in urban areas in order to reduce air pollution which brought the EV in demand. Furthermore, the ultra-sport EV disclosed by Tesla Motors at San Francisco International Auto Show in November 2006 is shown and could be sold in 2008 for a basis cost of $ 98,950 (www.pbs.org). In 2007 the G.M. developed "volt" electric models.

Following, the Israel government stated the support on a project to support the utilization of EV in January 2008. In July of the same year, the fuel or gas prices increased and American carmakers altered their fabrication from SUVs and larger vehicles for smaller more energy effective vehicles. Thoughtful about climate change and preserving the environment, the presidential candidate in the U.S. Barack Obama stated he will encourage to bear in America near 2015 one million plug-in hybrid and electric vehicles. In the U.K. the Prime Minister Gordon Brown announced in April 2009 that the British government will stimulate the use of EVs by subsiding a £2,000 for purchase on an EV. They estimated that 40% of all vehicles in Britain will be electric or hybrid in order to reach their objective of reducing by 80% of their CO2 emissions by 2050. Again in 2009 June, loans and support are given to car manufactures to develop fuel efficient vehicles which encouraged Tesla motors, Ford and Nissan. Tesla released the first EV: Tesla Roadster Electric. Mitsubishi also released i-MiEV in Japan. In the late 2009, even though a limited EV and hybrids existed on the market, several models like Nissan LEAF, Chevrolet Volt, Toyota Prius hybrid provided wholly EVs. In 2010, i-MiEV sport concept was released, Finland celebrated the success "think electric" car and Nissan LEAF electric was available in the U.S.

In fact, the EV has been more popular between 1905 and 1915. At each energy crisis the EV succeeded but have not gain the commercial success but actually, the commercial success is happening for example with the Toyota Prius, Honda Insight, Tesla etc. (Pierre Duysinx, 2013). The EV will need a rough way to befit a practical alternative to many users even though there are encouraging indicators. There are still some confronts like battery life, shorter distance, high purchase price or cost, additional structures to support EV, the charging stations which are still insufficient and more developed technologies related to EVs.

2.2. Development of EVs records on autonomy and travelled distances

The EV is considered as one of the solution in clean energy for transport. For this case, the IEA (International Energy Agency) launched a program in 2009 in order to hasten the use of EV in the World with the aim of an overall use of 20 million EVs in 2020 (IEA, 2016). The EV dynamics is placed in industry context as the manufactures are encouraged and buyers or purchasers are aware of climate change and the importance of an EV especially in urban areas. EV models have been emitted or proclaimed already by main OEMs. The number of EV releases (including hybrids) has increased every year since 2010. The governments throughout Europe are encouraging EVs by delivering a sort of subsidies and other welfares, on both sides of the demand and supply. The electric vehicles can be classified according to the powertrain in 4 categories. First the hybrid electric vehicles (HEV) and plug-in hybrid electric vehicle (PHEV), second the range extended electric vehicle (REEV), third the battery electric vehicle

(BEV) and fourth the fuel cell electric vehicle (FCEV). The last three (REEV, BEV and FCEV) possess an electric motor as the prime carrier and first (the HEV and PHEV) has ICE (internal combustion engine) as the prime resource of propulsion.

The HEV has a parallel hybrid configuration of electric and ICE drive which is optional for PHEV. ICE is the prime transporter of the vehicle with sustenance from tiny electric motor but based on the vehicle model, PHEV might have either electric motor or an ICE as the principal source of propulsion. It has a small battery which is charged by the ICE. It can be completely electric merely when driven at lesser distance and for low speed. It has a greater fuel economy than the conventional ICE with similar range (Amsterdam Roundtables Foundation, 2014).

The REEV has a sequence hybrid configuration of ICE drive and electric. It has at times tinier battery capacity than BEV and has a medium range electric driving. The vehicle can be charged from the grid (plugged-in). It has a slighter ICE-based generator for higher range, called ‘range extender’, as compared to BEV (Amsterdam Roundtables Foundation, 2014).

The BEV is a completely electric vehicle. It has a great battery capacity which is a Li-ion technology, has a short-medium range and it is only charged from the network when not moving (Amsterdam Roundtables Foundation, 2014).

The FCEV which is a medium-high range has a series configuration of electric drive and a fuel cell system. This last is a tack based on PEM (precise electrochemical machining) technology. The FCEV’s hydrogen tank pressure capacity is naturally 350 or 700 bar (Amsterdam Roundtables Foundation, 2014). According to the same report (Amsterdam Roundtables Foundation, 2014), based on the environment, advantages and obstacles, the EVs impact differently. Emissions are lowered with the PHEV because of battery and electric motor but still the principal or primary source of propulsion is ICE. The advantages of a PHEV is that it utilizes the current fuel structure and has a comparable range as an ICE vehicle. The challenges for a PHEV are that they have minimal range on exactly electric motor and the ICE which is the prime source of propulsion releases greenhouse gas emissions when trips are longer. Next, compared to ICE, significant emissions are reduced for the REEV and there are emissions only when range extender is utilized. The advantages of the extender are that REEV offers higher range than BEV and it is a true electric. The challenges of REEV are that the extender presents a rationed extra range and it is complex and costly compared to BEV. Following, the BEV are said to be the zero emission vehicles (except the generation of electricity to charge the vehicle) and more effective than ICE. The advantages of BEV are that they are total electric with zero emissions and can be charged at home but it has some challenges that charging can last a long time, has fairly low current range and the availability is still limited. Lastly, the FCEV are also zero emission vehicles (except the generation of electricity to charge the vehicle) and more effective than ICE. The advantages of FCEV is that it has a high range and refilling does not take much time. The obstacles of FCEV are that to generate hydrogen demand too much energy and the compulsory hydrogen structure is extremely limited at that time. The charging for the FCEV and REEV is simply filling hydrogen at a hydrogen refilling station which takes only about 5 minutes (an example of FCEV is Hyundai ix35). The vehicles that use a plug are PHEVs and BEVs that socket in to a charging post or at home using a cable and a socket. The charging takes longer, it takes about 4 to 8 hours (for slow) or 20 to 30 minutes (for fast). In Europe the availability was limited in 2014 where for slow charging there were around 20,000 stations and for fast charging about 1,000 charging stations (an example of BEV is Renault ZOE). However for specific BEV which are appropriate for battery switching, it takes about 5 minutes to exchange the discharged battery for an entirely charged battery at an exchanging station like superchargers of Tesla model S. There are also some technologies where the battery in the car is charged by wireless induction. This takes about 2 to 8 hours and this technology is still in experimental phase. Afterwards, the strategy plans to encourage the increase of charging stations is established in many countries.

Talking about the EV autonomy, Renault ZOE 100% electric with a new battery so-called "Z.E.40" full battery (41 kWh) and available now has an autonomy record of 400 km NEDC which is almost the double compared to the regular battery from its launching (22 kWh). This new autonomy concedes to travel 300 km on the urban and suburban routes in real time (Renault Presse, 2017). Now in France, the Caradisiac tried Renault ZOE until the 19th try where they reached 710.4 km on a speed of 35 km/h with a consumption of 13.4 Kwh/100 km (www.automobile-propre.com). Next, the autonomy of Tesla model S P100D in one charge was about 900 km, precisely 901.2 km which has been travelled on Belgian routes by two Belgians Steven Peeters and Joeri Cools with battery pack of 100 kWh (the biggest proposed by Tesla) driving with the average speed of 40 km/h. This record is done in 23 hours and 45 minutes (www.automobile-propre.com). But few weeks later, in the beginning of August 2017, there is a new record from Tesla model S 100D which is gained in one and simple charge where the vehicle travelled 1,078 km on an adequate speed of 35.4 km/h (www.numerama.com). Actually, Tesla model 3 is not too much expensive as before because the price for a new Tesla model 3 starts at $ 35,000 and is to be emitted by the end of 2017. This car will go no less than 215 miles which is about 346 km in one simple charge. Tesla has for now more than 130,000 preorders on this model. But still, the model S and X are very expensive, new ones are about $ 100,000 (https://www.theverge.com) and used ones around $ 55,000 but this amount varies. It is only the new Tesla model 3 that is cheaper.

According to www.avem.fr, the autonomy and price of other future vehicle make models from 2016 to 2019 of vehicle manufacturers' projects are: Opel Ampera with an autonomy of 500 km NEDC available in 2017 with a Lithium-ion battery at a price of 27,000 € TTC bonus deducted. Then Smart Fortwo Electric drive 4th generation with an autonomy of 160 km NEDC with a speed of 125 km/h. It also uses Lithium-ion battery and is available in Europe since the beginning of 2017at a price of 16,990 € TTC bonus deducted. Toyota Mirai with the autonomy of 500 km at a speed of 178 km/h using a PAC + NiMH batteries and available already in France since 2017. Next, Chevrolet Bolt with the autonomy of 383 km depending the American norm EPA, available since 2016. Then, Chevrolet Spark EV with 132 km (EPA) of autonomy using a lithium-ion battery. Then, Citroën C1Ev'ie with an autonomy of 110km at 96 km/h of speed and also using a lithium-ion battery. Thereafter, Citroën E-Berlingo Multispace with 170 km of autonomy at a speed of 130 km/h using a lithium-ion battery too. Then, Fiat e500 available since the spring of 2013 with an autonomy between 130km to 160 km. Next, Ford Focus-e which has an autonomy varying between 250 km to 280 km (NEDC) also using a lithium-ion battery. The next vehicle make model is Mahindra Reva - e2o with a 100 km of autonomy travelling at a speed of 81 km/h with a lithium-ion battery too. Following is Mercedes SLS AMG Electric Drive with an autonomy of 250 km with a maximum speed of 250 km/h and is already available since June 2013. After, Peugeot Partner Tepee Electric with a 170 km of autonomy and travelling at a speed of 130 km/h using also a lithium-ion battery. The following is Porsche Mission E with an autonomy superior to 500 km on a maximum speed of 250 km/h. It will be available before 2020. The following vehicle is Softcar Upgo with 120 km of autonomy at a maximum speed of 90 km/h using a lithium-polymer battery. Then, Subaru R1e with an autonomy of 80 km at a maximum speed of 100 km/h using a lithium-ion battery. The next vehicle make is Toyota iQ electric with an autonomy of 85 km (NEDC) drove at a maximum speed of 125 km/h also using a lithium-ion battery. The next car is Tracelet Whoop with 140 km of autonomy at a maximum speed between 45km to 80 km depending on versions. Lastly it is Volvo available in 2019 with an autonomy of 480 km. Among these other models, the Toyota Mirai has now a best autonomy however Porsche exceeds when available but still Tesla model S 100D has the first distance autonomy record.

2.3. The climate change and EVs

Electric vehicles are considered as important answer to current challenges in climate change, energy and economic crisis because they help reduce gas emissions in transport sector and reduce dependence on fossil fuels so as oil savings. The main factors that encourage the EVs' preference are expressly the worries about climate change and global warming, security of energy and technology improvements of battery (Michael K. Hidrue et al., 2011). A target to decrease the carbon footprint is a strong enthusiasm for environmentally aware user to buy and utilize EVs. But also the cost savings because some governments subside the purchase of EVs and EV models are cheaper than their ICE counterparts when you consider their maintenances and oil prices. Some researches (in Europe) predict that automobiles will increase to a factor of 3 in 30 years (more than 3 million per year). If nothing is done, they predicted that in 2010 the traffic of heavy weights will increase of 50%. Therefore, the CO2 emissions in Europe in the truck (vehicle) transport will be 24%. From 1990 to 2010 the CO2 emissions increased by 50%. In addition, the security of energy supply in transport is dependent of petrol (fossil fuel) at 98% of which 70% is imported (Pierre Duysinx, 2013). The prediction in petrol resources are of 35 to 40 years whereas the petrol stocks are about 60 years. In urban hubs the pollution is much more worrisome especially in transportation. The transport sector contributes mainly in NOx, CO emissions and noise pollution which is significant challenge.

Compared to the US, China and Japan, the CO2 diminution objectives for transport across EU are impressive (Amsterdam Roundtables Foundation, 2014) targeting for a 95 g CO2/km limit by 2020; and policies are liable to further strengthen beyond 2020. For example, in 2013, a target of 68-78 g CO2/km was suggested for 2025, with the ultimate resolution on post 2020 goals tending to be attained in 2016. In addition, cities are taking measures to stimulate EVs use in order to reduce CO2 emissions and regulate NOx emissions which stretch with the EU Air Quality Directive of 2008 (Amsterdam Roundtables Foundation, 2014). Many governments in Europe have put adoption goals of EVs over few years with the purpose of to achieve the goals of energy independence, technology ownership and emissions reduction. Pooled EU objectives, that are to be conferred with member states, extent to 8-9 million EVs by 2020 however objectives and agendas differ broadly by member country. For example, Germany targets at 1 million by 2020, Spain expects to attain this number by the end of 2014, France has a goal of 2 million EVs by 2020, and the Netherlands has fixed its 2020 EV goal at 200,000, followed by an ambitious 1 million EVs just five years later in 2025. These ambitious goals may be challenging to realize in the majority of countries, still they indicate clear responsibility and assistance for EV adoption big level from national governments (Amsterdam Roundtables Foundation, 2014). According to this report, the use of renewable energies and spread generation that is enlarging along with the needs of improving energy efficiency concur with a developing acceptance of electric vehicle. Another research done about EV in Europe to reduce CO2 emission found that depending on electric power plant, the efficacy and the distance travelled, the emissions differ. For ICE vehicles, there are good results on longer distances driving and bad results on urban driving. If electricity generation is decarbonized, the EV entry in Europe will be beneficial and the GWP (Global Warming Potential) reduction in transport will come from driving patterns that affects both ICE vehicles and EVs. Consequently in the transport sector, the use of EVs will generally imply reductions in the net GHG emissions (Lluc Canals Casals et al., 2016). According to Gonçalo Duarte et al., BEV very employed in urban areas can be an alternative answer for the environment. To shift to BEV lower vehicle consumption where BEV offers 76% increase of efficiency on energy per distance, with savings in the TTW (Tank-To-Wheel) phase of 267 g of CO2/km and 0.364 g of NOx/km because of zero emissions. Yet BEV rivalry with ICEV is greatly touchy to parameters like purchase impulses, energy price, charging infrastructure condition, etc. (Gonçalo Duarte et al., 2016).

EV's LCA according to ISO 14040 has also been done to measure the EI (environmental impact) from raw material extraction to the end of life of EVs. There is an EI in EV's energy use (driving resistances, the use of auxiliaries and losses) which depends on the electricity mix: a mix built on fully renewable energies gives a best result than a mix based on fossil fuels yet an adequate mix is stiff. The used determining factors for LCA are driving behavior, desired temperature, topography and type of road. In a flat city area, heating, cooling and velocity are low, the consumption is 10 kWh/100km. In a hilly city area, heating, cooling and velocity are medium, the consumption is 15 kWh/100km. On highways and hilly regions, cooling and heating are medium but high velocity, thus the consumption is 20 kWh/100km. For raw materials, the steel has a lower EI than aluminium. The lower EI of one material to another depends on both the electricity mix and energy consumption in use. An energy mix with low CO2 emissions (e.g. Brazil) steel causes lower CO2 emissions and a mix with medium CO2 emissions (e.g. Germany) aluminium is a better choice (Patricia Egede et al., 2015). Hawkins et al. found that EVs powered by the present European electricity mix offer a 10% to 24% decrease in GWP relative to conventional diesel or gasoline vehicles assuming lifetimes of 150,000 km (Hawkins et al., 2013). In Europe, EVs reduce oil use and air pollution than ICEVs and as the electricity is lower than petrol per vehicle-km, EVs has lower operating costs.

2.4. The EV market

This section enlightens the literature about the market of EVs, the most recent progresses in new registrations and reserves of EVs, first electric cars, second the market itself and last the trends or developments.

2.4.1. The market of EVs

The progress of the EV market specifically the electric cars (battery electric and plug-in hybrid) is explained by the growth of 70% amongst 2014 and 2015, with over 550,000 vehicles that are retailed during 2015 in the World. China was the major market for electric cars during 2015 and surpassed the U.S. with over 200,000 further enlisting, because the market weakened in the U.S. between 2014 and 2015 but had a significant progress in China. These two markets altogether credited for more than a half of the overall new EV enlisting in 2015 (IEA, 2016). By 2015, 90% of the EV trades happened in principal electric car markets which are respectively China, the U.S., the Netherlands, Norway, the U.K., Japan and France which had a significant growth between 2014 and 2015 excluding Japan and the U.S. The sales doubled in the Netherlands (10%), the highest in European Union and the second highest globally after Norway (23%). These two have the highest market shares. They instigated ways that encourage users to choose for EVs. For example in the Netherlands, they have meaningful discount on registering and travel taxes along with restricted access to a few parts of transport network limited for other cars. Hard intensives are specified by Norway in registration and tax reductions too, etc. in fact, most developed countries encourage the use of EVs and have implemented policies to support the use of EVs. The purchase of the EV are the most pertinent (financially) and the most efficient but additional study is required to evaluate well the effects of non-fiscal, local and infrastructure achievements. Some purchase intensives' features are searched and we can summarize it as follows:

By 2020, the EVs in the Belgium roads is 2%. Between 2025 and 2030 the EVs on roads should increase up to 5%. The tax system deducts for companies under trade tax system 120% of purchasing a 100% EV or PHEV with CO_2 less than 60 g/km. The residential market is been reduced 30% of the purchase price of an EV and in Wallonia, the supplementary inducement for the acquisition of an EV via bonus-malus system is up to 3,500 €. Also, the companies under trade tax system have 100% deductibility of purchase cost of a PHEV with CO2 less than 60 g/km. In China, the tax is centered on the cost and engine dislocation. To purchase an EV the value was in the span of USD 6,000 TO USD 10,000 (IEA, 2016). In 2013 in France, they proposed the intensives to purchase of 6,300 euros for cars releasing less than 20 grams of CO2 per kilometer and 1,000 euros for vehicles releasing between 20 grams of CO2 per kilometer and 60 grams of CO2 per kilometer. Meanwhile in Japan, the subsidies are built on the fee variance amongst an EV and an equivalent gasoline vehicle with a maximum of about USD 7,800. Encouragements quantify from EUR 3000 to EUR 5000 for a typical BEVs and PHEVs. (Mock and Yang, 2014). Next, in the Netherlands vehicles releasing zero CO2 are discharged to pay registering tax in 2016, other vehicles pay depending on the upturn of CO2 emissions per kilometer. This gives important advantages for EVs or plug-in hybrids vehicles. For Norway the EVs are excused from purchase taxes (equivalent to USD 12,000) and BEVs are also excused from VAT (25% of the vehicle cost before tax) but it is not applicable for PHEVs (Mock and Yang, 2014). Following in Portugal the BEVs are discharged from automobile registration (about 1,250 euros) and flow taxes. For consumers, an extra of 4,500 euros is proffered (IEA, 2016). Then in Sweden, the emissions below 50 grams CO2 per kilometer are conferred an equivalent of 4,000 euros (IEA, 2016). For the United Kingdom, there is a purchase inducement equivalent to USD 6,300 obtained by BEVs for cars and USD 11,200 for light commercial vehicles, then the PHEVs under USD 84,000 obtain inducement of USD3,500 (IEA, 2016). Finally in the United States USD 7,500 are abridged on tolls on EVs at the national level. PHEV with all electric varieties (18 km to 40 km) obtain acclaims of USD 2,500 to USD 4,000. Further BEVs and some PHEVs get the utmost of USD 7,500. In addition, the states also apply purchase incentives. At the state level (Jin, Searle and Lutsey, 2014) anticipated a span amid USD 1,000 and USD 6,000 for the BEV and PHEV purchase inducement. The EV acceptance levels are being seen in numerous European countries. Norway is the leader in Europe with EVs enhancing up to 6.2% of overall car sales in 2013. In another research done in the U.S.A. the user's intent to acquire or rent a plug-in electric vehicle is still small. The preference is bigger for a plug-in hybrid than for an all-electric vehicles. This is because they think that a PHEV is more practical in urban routes, for their travel behavior and can run longer distances due to the additional ICE than the PEV. The ones who find it beneficial and want to adopt are those who are environmentally aware, extremely educated or have already an experience with a hybrid vehicle and do not want to stay dependent on fossil fuel. But there are two types of people, those who are prevented to purchase an EV because of three main factors which are related to the high amount of purchase, the slow time of recharging and the range. The second type of people are few others who do not take those factors as disadvantages and trust using an EV as beneficial because they take care of the environment, like technology novelty and save fuel (Carley S. et al., 2013).

According to Michael K. Hidrue (Michael K. Hidrue et al., 2011), the study of the appraisal of the eagerness to repay for five EV characteristics that are driving range, charging time, fuel cost saving, pollution reduction, and operation concluded that the user's principal worries about EVs are the acquisition price which is high, the lengthy charging time and range anxiety. The people estimate the driving range from $ 35 to $ 75 per mile (1 mile is almost 1.61 km) and charging time at $425 to $3250 ($1 approximately 0.85 € on August 9, 2017). Furthermore, the study implies that prior to finding a big market of EVs deprived of subsidy, the price of battery have to decrease considerably. Furthermore, the tendency of a consumer to purchase an EV rises with education, environmentally sensitive people, younger generation, high oil price and the accessibility to recharge a vehicle. The study showed that most people were preferring an EV especially for eluding oil prices and not for the environment. Another example in Australia where the transport fleet represents 8% of national greenhouse emissions has been a case study for its urban areas simply to see the costs and the transition towards EVs. They compared two scenarios which were high cost and low cost scenarios. In the first scenario they found (measured on 2015 to 2035) a fast transfer to EVs will cost 25% more than the ongoing usage of ICE vehicles. For the second scenario, the costs of battery EVs principally will drop more quickly, only the maintenance costs of EV at the lower end of prognoses. Propositions to shift to EV for urban areas are that the cost might be reduced and use plans and strategies for the climate change. In fact, in the high cost scenario, the total costs were estimated to be $993 billion if they continue using ICE and if they transit to 100% electric then the costs will be 25% higher. And in the low cost scenario, the costs are significantly reduced due to lower electricity costs when compared to fuel costs and lower maintenance costs. The quick shift to EVs to lessen emissions could be cost efficient under requirements like capital, battery and maintenance costs of EV are at the forecasts low end, and fossil fuel prices increase to the forecasts high end, so a quick change to EVs might not cost more than continuous usage of ICE vehicles (Jenny Riesz et al., 2016). Actually, the top EV market countries are China first and U.S.A. which sale more than a half of EVs in the world (cleantechnica.com, 2017).

The market of vehicles in Belgium is still dominated by diesel vehicles and Belgium has the highest market shares of diesel vehicles but the share of electric and hybrid vehicle is still very limited. Toyota begun sales in 2012 when it sold its Prius plug-in hybrid model. In addition, hybrid and pure electric that are in Belgian routes are mainly the Tesla Roadster and some heavy-duty hybrid vehicles in trucks and buses. The public buses increased its hybrid buses since 2009. Belgium has also a quickly growing market of Tesla since 2013 and will set up additional outlets and charging stations.

2.4.2. Recent registrations of EVs

The new EVs registrations sales in November 2013 attained 12% (1,434 of a total of 12,079). The overall top-selling model in 2013 was Norway on full BEVs which were Nissan LEAF and Tesla model S (Amsterdam Roundtables Foundation, 2014). In the EVI country members, the registered EVs were about 20.000 in only 2010. This number increased and was 0.89 million in 2014. It continued to increase and attained 1.45 million EVs in 2015 (IEA, 2016). Seeing these numbers show that the increase of purchasing the EVs is approximately 2.2% from 2010 to 2014 and then 1.4% in 5 years (2010-2015) which is still less. The civic accessible charging infrastructure is also very less worldwide. For this reason, there could be fewer users of EVs. But in order to sensitize and encourage the use of EVs adoption, the national and local governments must sustain the positioning of the charging infrastructures either public, at work or at home. In Belgium, August 2010, the total of registered vehicles was 6.7 million amongst them there were only 1,295 EVs. There were in Belgium 3,900 registered EV and nearly 600 public EV recharging stations.

2.4.3. New trends or developments of EVs and Early-Adopters

In Europe the three major potencies that motivate to choose the EVs are consumer demand, industry developments and government stimulus (Amsterdam Roundtables Foundation, 2014). The process for trends and new developments of EVs is set differently depending on the country's targets for 2020 – 2030. For Belgium, they subsidy € 5000 in purchasing an EV or a zero-emissions hydrogen-powered vehicle. In China the goal of 5 million EV is combined with the EVSE positioning of 4.3 million private EVSE store and 0.5 million public chargers. European Union must also outline the electric charging point targets. The European Commission's suggestions involved an EU-wide goal of 800,000 open chargers in public and a totality of 8 million chargers by 2020 (IEA, 2016). By 2030 in France they will install 7 million outlets for charging. While in India their 2020 strategy alludes high gas/PHEV deployment of 175,000 charging points and high gas/PHEV/BEV of 227,000 charging points. In Japan, the

NGVP (Next Generation Vehicle Plan) aims to install 2 million typical chargers and 5,000 fast chargers by 2020 and The METI (Ministry of Economy, Trade and Industry) in 2016 has set a new target for 2020 of 1 million EVs (METI, 2010).

The early adoption of EVs in Europe flourished in 2013 and further growth appeared to set by 2014. The barriers mentioned to EVs adoption are high costs, range concern, low understanding and battery capacity. Most major European countries' governments push EV growth which comes from the desire for higher energy independence and a shift towards a less oil intensive transport sector. The purpose to innovate the development of EV technology and retain the value shackle in countries is being spotlighted by governments with major OEMs, so that in the forthcoming years, the EV adoption could considerably be uplifted by wider trends with both consumers and OEMs (Amsterdam Roundtables Foundation, 2014). The authorities should implement fiscal edges in buying an EV or in electricity for recharging the EVs. For 2020 the EV penetration rates on electricity demand is approximately 2% on the road vehicle fleet and around 5% in 2030. Up to 2020 the EV consumption of electricity is rather small: between 0.4 and 0.5 TWh but until 2025 and 2030 it will increase to 1.2 and 1.4 TWh which is nearly 1% of the total final electricity demand in 2030 (Federal Planning Bureau, 2010).

2.5. EV in Belgium specifically in Wallonia (study zone)

The 2030 European intentions are 50% more efficiency that include to decarbonize, the global competitiveness, reliability and security. For the European industry, the aim is to design and produce the most performing internal combustion engines. To ameliorate the combustion engine, industries have to use electronics, direct injection, optimize the combustion and downsize the engine without losing its performance. Next, utilize the electric motors and the design of more developed vehicles. Again in transport, the goal is to decarbonize and the use more effective fossil energy resources and renewable energies. In fact, especially in urban areas to walk by foot, bicycles like e-bikes, battery electric, plug-in or range-extender in addition especially to increase the share of renewable energies in electricity production and the use of bio fuels in transports. The aim is to shift from combustion engines to alternative fuels or zero carbon motors. The EV is still a niche market but hybrid vehicles are growing compared to electric. To reduce the CO2 emissions, they have to use the hydrogen or natural gas, the electric vehicles, hybrid vehicles and fuel cell. For an EV, the consumers want specifically a better autonomy, the less time of recharging and a maximum reliability. This varies depending on the moment of the day and the place. Thus there may be some CO2 emissions on the traditional power plant.

The Belgian electricity mix on August 3rd 2017 is made of 81% of low-carbon mainly because of the nuclear energy which is three quarts of it, and other 19% comes from the gas power stations. In fact the mix is composed of nuclear energy (68%), gas (19%), solar (5%), wind power (2%), hydro (1%) and other (5%). Other refer to biofuels, biomass etc. (https://forumnucleaire.be). The final RE (renewable energy) consumption since 2005 to 2014 has increased from 2% to 8%. The 2020 objective is to reach a share of 13% and 18% by 2030 of RE in the electricity mix even though it is still challenging. The regions of Belgium has their own objectives. RE in Brussels represents 2.3% (with 2020 objective of 3.8%), Flanders has 5.7% of RE (with 2020 objective of 10.5%) and Wallonia has 10.8% (with 2020 objective of 13%). It is clear that Wallonia represents the highest incursion ratio. It is positive that there is an increase of renewable electricity and the incorporation of biofuels in the distribution of street fuel (www.apere.org). It can also be positive to use an EV in Wallonia our study region.

For 2030 fixed objectives of Belgium which is 50% more energy effective, different studies estimate that the EV is a response of decarbonizing in urban transport. Hence, the transport efficiency is also helped by the advance in telecommunication and technologies. Accordingly, the adoption of EV will require the change in consumption and utilization behavior. (Pierre Duysinx, 2013).

The goal of Belgium by 2020 to use EVs on its roads to reduce the emissions is 2%. Between 2025 and 2030 the EVs on roads should increase up to 5% and it will have a noticeable effect of between 1.2 and 1.4 TWh of electricity. This consumption shows about 1% of the total necessity of electricity in 2030 (Federal Planning Bureau, 2010). The main global policy measures taken for an EV are specifically economic measures, road traffic policies and funds in charging infrastructure (Theo Lieven, 2015), for example there are actually only 5 Tesla superchargers in Belgium (in Ghent, Kortrijk, Nivelles, Aartselaar and in Brussels) but other charging stations for other EV makes for example at home, slow and fast conductive, inductive or swapping rechargers. In general, the weaknesses of EVs are mainly the driving range and the cost of the vehicles. Belgium encourages clean vehicles (like EVs) by deducting the tax of vehicle companies based on the vehicle's CO2 emissions. Then the EV fixed tax cost are deducted at a rate of 120% so even if EVs are costly compared to ICEVs, these EVs would get a bigger subsidy. Although the supports of EVs, they are utilized mostly by the elite group while other older and non EV are used by lower income groups. The most sold vehicle since 2010 is Tesla Roadster (eight out of fifteen EV) with the cost of 84,000 € (Kobe and Thomas, 2017). In addition as said above in the literature, in order to motivate residents in Wallonia to buy an EV the supplementary inducement for buying an EV via bonus-malus system is up to 3,500 €.

These days in Wallonia what can influence the choice of electric vehicles over diesel/petrol vehicles? The degree, professional status, finance or household income, travelled distance from home to work/study or leisure, government stimulation, early adoption, environment, battery technologies, comfort, reliability, security, higher price of fossil fuel (diesel/petrol) can be influencing factors to choose and / or purchase an electric vehicle.

III. METHODOLOGY

The use of an EV is still less in Wallonia, and this study will show the population’s reactions about EVs. The methods used to see and predict the use of EV in Wallonia are described here.

3.1. Introduction

The techniques used for this research for the collection of the data is a questionnaire survey where respondents gave their thoughts and ideas about the EV. After data collection, the data are analyzed and treated in R software to get results and findings. Different methods in are used, to clean the data first, then create a database to be used for treatments in R software.

3.2. Process of data collection

The data used are collected randomly by ourselves in Wallonia which has a total of 262 communes. Wallonia is a southern Belgian Region with Namur as capital. It is bordered by France in South-West, with Grand Duchy of Luxembourg in East, Germany in East, The Netherlands and Flanders Region in North. Wallonia has five Provinces with a population from a census of 2015 as follows: Hainaut with 1,335,360 of population; Liège with 1,094,791 of population; Luxembourg with a population of 278,748; Namur with 487,145 of population and Walloon Brabant which has a population of 393,700 (connaitrelawallonie.wallonie.be).

To collect the data, a survey questionnaire is used which is composed of 40 questions. It is written in French both on hard copies and on internet. The respondents answered questions either online or with hard copies. The online link and the hard copies are attached in this research in the appendices. We had to go in each chosen commune and select randomly the respondents whom wanted to reply to the questionnaire. The hard copies distributed randomly on the field were either recuperated at the same day or recuperated a week later when we go back there. The approach used to choose communes in each province is done over R and excel software. The technique used is called random walk sampling: it is a technique in which the number of strides between sample points is calculated by random number charts and from every sample point a right-angle gives the direction of the next point. In fact, having the number of population of each commune in each province, we had to select first in a province a commune with the highest number of population, then divide by 3 (because we took 4 communes in each province) and take the remaining 3 communes the last one having a lower number of population in that province. We distributed both hard copies and a flyer that contained the online link so that respondents who wish to answer online could to it at home or once they get time. The problem encountered during data collection were that most of the people did not have time to respond, others did not complete all the questions, because of that, they have been disqualified. The target was 300 respondents for all the communes mentioned in the table below.

Commune	Province	Target number of respondents
Charleroi	Hainaut	90
Dour	Hainaut	8
Soignies	Hainaut	12
Silly	Hainaut	4
Liège	Liège	79
Herve	Liège	7
Comblain-au-Pont	Liège	3
Raeren	Liège	5
Aubange	Luxembourg	7
Arlon	Luxembourg	12
Vielsalm	Luxembourg	4
Libin	Luxembourg	3
Namur	Namur	32
Floreffe	Namur	3

Ciney	Namur	5
Philippeville	Namur	3
Braine-l'Alleud	Walloon Brabant	17
Nivelles	Walloon Brabant	11
Chastre	Walloon Brabant	4
Perwez	Walloon Brabant	4
Number of observations		300

Table 1: Surveyed commune

Another problem was that even though we distributed hard copies and online link to respondents in the exact study place of chosen commune, there were some who were there but do not live

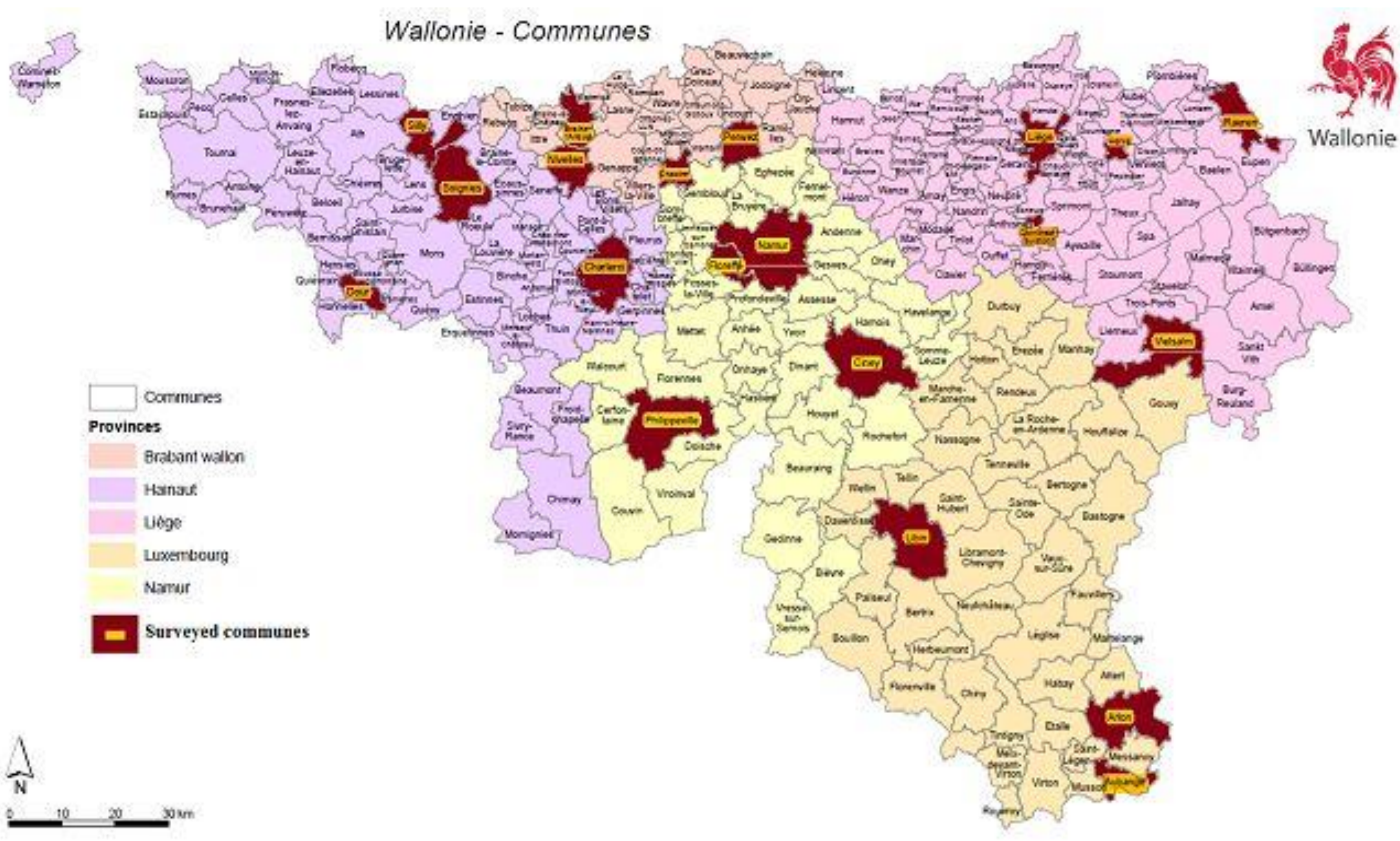


Figure 2: Wallonia Communes with surveyed communes (map source: www.connaitrelawallonie.wallonie.be/fr/la-wallonie-en-bref/geographie#.WZWpHuLRbMI)

However when data collection is finished, the total respondents were 278 because the time was limit and we couldn’t wait for all respondents and stopped at almost 93% of the target number.

#	Answer	%	Count
1	Un homme	52.88%	147
2	Une femme	47.12%	131
	Total	100%	278

Table 2: Total respondents before data cleaning

Unfortunately all 93% were not used because when we cleaned the data, we removed all who did not answer the questionnaire in full and the ones who answered in full but reside outside the study area were also eliminated. The final sample considered for the study is of **223** respondents (74% of the target). This is the final sample used for this research.

3.3. Analysis and treatments

The techniques used to analyze the data are descriptive analysis, linear regression and logit - probit analysis. These methods are used because of the form of the questions asked in order to know the description of respondents which is especially the socio-demographic questions. Next, using the linear regression helps understand the relationships or associations between variables and do the regression model. Last, the logit model enables predicting the probabilities of variables depending on different factors and see what makes people to prefer or not to use EV.

3.3.1. Cleaning the data and creating a database

The first step before starting the analysis and treatments, the data are cleaned. It means we eliminated all respondents who did not complete all the questions, next we removed the ones who completed the questionnaire in full but are outside of the study area. The remaining sample is composed of 223 respondents. The next step consists of creating a database. The database has been created in SPSS software. Each question has been given a corresponding variable. Those variables are the ones that are going to be used in all treatments. Following is the table explaining every variable with its corresponding question /explanation.

Number	Variable	Corresponding question / explanation
1	id	Identity
2	Gender	Gender
3	YOB	Year of birth
4	PC	Postal code

5	Municipality	Commune
6	Degree	Degree
7	ProStat	Professional status
8	MarStat	Marital status
9	LivSit	Living situation (family composition)
10	HHSize	Household size
11	HHInc	Household income
12	DrivLic	Driving license
13	NrCars	Number of cars
14	DriverKM	Driven kilometer per year
15	HWSDist	Home to work/study distance per day
16	HWSMode	Home to work/study most used mode
17	HWSFreq	Home to work/study frequency
18	SLFreq	Home to leisure/shop frequency
19	DExpEV	Drive experience with EV
20	DExpHYB	Drive experience with hybrid
21	ExpOEM	Drive experience with electric bike
22	TQM	Talbot's Q method for FACTOR 1 to 6 (question 21 of choosing and ordering)
23	BSFIS	Standardized factors score
24	SCAFD	Self-Categorization Approach (Question 29 of balloon)
25	EV_CONSIDER	EV consideration (thinking to use EV)
26	EV_NEARFUTURE	EV in near future (thinking to buy it in near future)
27	EV_PURCHASE	EV purchase (want to but EV)
28	EV_WORK	EV for work (using it to go to work)
29	EV_PEER	EV peer (people think I could buy an EV)
30	EV_PEEREXP	EV peer experience (I am going to buy an EV)
31	EV_ABPURCHASE	EV about to purchase (if I want I can buy an EV)
32	EV_ABDRIVING	EV about to drive (if I want I can drive an EV)
33	EV_ENV	EV for environment (EV contribute to a good environment)
34	EV_FINANCE	EV no finance (not financially possible to buy an EV)
35	EV_PREFEV	EV preferred over petrol/diesel vehicle
36	LIM_PRICE	Limited by price (EV expensive)

37	LIM_DISTANCE	Limited by distance (EV drive shorter distance)
38	LIM_BATTERY	Limited by the battery (battery emptying)
39	LIM_RELIABLE	Limited by the reliability (EV not reliable)
40	LIM_SAFETY	Limited by safety (EV not safe)
41	ADV_ENV	Advantage for environment (EV is good for environment)
42	ADV_COMFORT	Advantage of comfort (EV is comfortable)
43	ADV_SAFETY	Advantage of safety (EV is safe)
44	ADV_RELIABLE	Advantage for reliability (EV is reliable)
45	ADV_OILPRICE	Advantage of oil price (higher oil price)
F1	FACTOR1	Environmentally aware at any cost
F2	FACTOR2	Usability and reliability crucial
F3	FACTOR3	Equivalent transition
F4	FACTOR4	Transition with only benefits
F5	FACTOR5	Early adopters
F6	FACTOR6	Urban liveability

Table 3: Variable used with its corresponding question / explanation

3.3.2. Descriptive statistical analysis

Descriptive statistics is a method used to describe or summarize the data which are here a sample of 223 persons of Wallonia population. This method allows to measure central tendency (mean, median and mode), spread or variability (standard deviation, variance, minimum and maximum variables, the kurtosis and skewness). Before doing the descriptive statistics analysis and after cleaning the data, we imported the spss database in R software. Recall some formulas:

Sample mean: where n = number of the sample

$$\bar{y} = (y_1 + y_2 + \ldots + y_n)/n = \frac{1}{n}\sum_{i=1}^{n} y_i$$

Sample variance and standard deviation:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2 \quad \text{and} \quad s = \sqrt{s^2}$$

3.3.3. Linear regression

Linear regression is a method used to model the relationship between a criterion variable (dependent variable) and one or more predictor variables (independent variables). The linear regression can be simple (one independent variable) or multiple (two or more independent variables). The linear regression is given by the model:

$Y = \beta_0 + \beta_i * X_i + \varepsilon_i$ Where $\varepsilon_i \sim N(0,\delta^2)$ is the error; β_0 is the intercept; β_i is the regression coefficient or slope; $\beta_0 + \beta_i * X_i$ is the regression line.

This model indicates that for a given value of X_i: $Y_i|X_i \sim N(\beta_0 + \beta_i * X_i, \delta^2)$.

The $Y_i|X_i$ emphasizes that the distribution of Yi is conditional on Xi.

The observations Yi are normally distributed about the point on the regression line, with constant variance which means: $Y|X \sim N(\beta_0 + \beta X, \delta^2)$.

This model can be interpreted as β is the average increase of Y when X increases with one unit. When regression is finished, we look at the p values to see if there is a relationship. Given a confidence interval (CI) of 95% which means that at a probability of 95% there is relationship.

3.3.4. Logit - Probit analysis

Logit or logistic regression is alike to linear regression the large difference is that logit uses the logit link function. It is a suitable regression analysis to use when the dependent variable is binary (yes or no, agree or disagree, like or dislike etc.). Logit analysis is also a predictive analysis, it is used to describe the relationship between one dependent binary variable and one or more independent variables which can be nominal, interval, ordinal or ratio-level. A logit is the conversion of a proportion which will linearize the logistic curve, logit (p) = log (p / (1 − p)). When Y is categorical, logit of Y is used as the response in the regression equation instead of just Y:

$$\mathrm{Ln}\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n$$

Probit is similar to logit model, it just uses a probit link function, assessed utmost utilizing the standard maximum likelihood technique.

3.4. Validity

To validate the models (linear, logit and probit), we looked at p-values and then see if we are not able to reject the null hypotheses or reject it in favor of the alternative hypothesis. Then the model could be validated if there is association or not if there is no association. When we validate a model, we give the equation of the linear model or the predicted probability in case of logit - probit models.

3.5. Methodological assumptions

The methodologies used are chosen because of the form of the questionnaire and given answers. Some limitations are that we had to change the format of data like making them numeric or factors and reshaping the data from wide to long or vice versa for the codes to run. Otherwise the methods, analysis and treatments are perfect.

IV. RESULTS

4.1. Brief overview

The results we obtained during the analysis treatments over the R software are presented in this chapter. These are descriptive statistics, linear regression and logit - probit results. As stated before, the sample comes from a questionnaire survey encountered in Wallonia. It is a sample of 223.

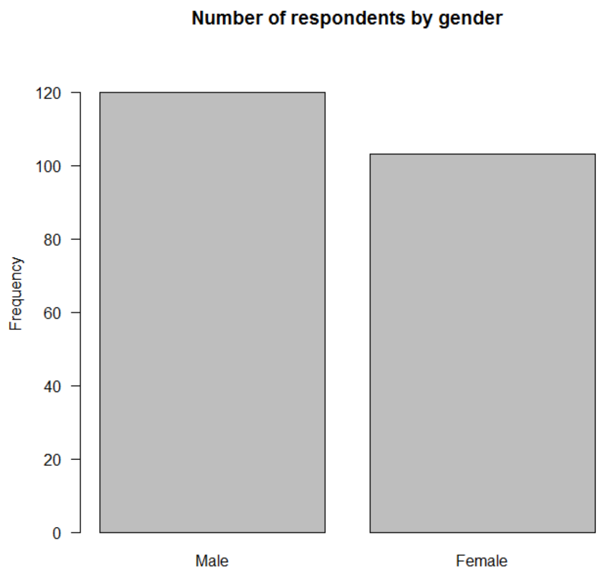


Figure 3: Plotting male and female respondents.

Before starting any treatment, the database have been created in SPSS and imported in R and the database is called EV. The whole script is presented in the appendices. After importing the database we attached its file "EV" file to make the code easier.

4.2. Descriptive statistics

The results of descriptive statistics in R, are given by the “summary” function. The important results of this method are presented below.

```
> summary(EV)
       id            Gender          YOB                                         Degree                  ProStat                          MarStat
 Min.   :  1.0   Male  :120   Min.   :1943   None                                : 1   White collar worker:98   Single                    :105
 1st Qu.: 56.5   Female:103   1st Qu.:1972   Primary school                      : 3   Student            :44   Maried                    : 75
 Median :112.0                Median :1984   Secondary school                    :60   Civil servant      :31   Formally living together: 20
 Mean   :112.0                Mean   :1981   Higher education (not university):67   Independent        :21   Divorced                  : 15
 3rd Qu.:167.5                3rd Qu.:1990   Higher education (university)      :74   Blue collar worker :15   Widowed                   :  8
 Max.   :223.0                Max.   :1999   Post-university education          :18   Unemployed         : 5
                                                                                       (Other)            : 9

                                          LivSit            DriverKM               HWSDist                  HWSMode                       HWSFreq
 Alone                                     :48   10000-15000 km      :52   No study/work: 9   Car (as driver)          :135   Multiple times per day : 34
 With partner                              :38   15000-20000 km      :40   < 5 km       :32   Bus (TEC/De Lijn/STIB): 38   One time per day       :124
 With partner and children                 :72   0 km (Don't drive car):39  5-10 km      :58   By foot                  : 13   Multiple times per week: 54
 Alone with children                       :13   5000-10000 km       :29   10-20 km     :62   Train                    : 11   One time per week      :  0
 With parents in a single parent household:19   20000-25000 km      :24   20-50 km     :42   No study/work            :  9   Less than once per week:  2
 With parents in a two-parents household  :23   < 5000 km           :21   50-100 km    :16   Car (as passanger)       :  8   Not (no study work)    :  9
 Other                                     :10   (Other)             :18   > 100 km     : 4   (Other)                  :  9

                  SLFreq     DExpEV                                            TQM                                                       BSFIS
 Multiple times per day :  4  Yes: 12   Factor 1: "Environmentally aware at any cost":61   Factor 1: "Environmentally aware at any cost":36
 One time per day       :  7  No :211   Factor 2: "Usability and reliability crucial":17   Factor 2: "Usability and reliability crucial":40
 Multiple times per week:103            Factor 3: "Equivalent transition"             : 3   Factor 3: "Equivalent transition"             :34
 One time per week      : 71  DExpHYB   ExpOEM  Factor 4: "Transition with only benefits"     :91   Factor 4: "Transition with only benefits"     :45
 Less than once per week: 38  Yes: 23  Yes: 42  Factor 5: "Early adopters"                    :15   Factor 5: "Early adopters"                    :32
                              No :200  No :181  Factor 6: "Urban liveability"                 :36   Factor 6: "Urban liveability"                 :36

                                          SCAFD  EV_PREFEV LIM_PRICE LIM_DISTANCE LIM_BATTERY LIM_RELIABLE LIM_SAFETY ADV_ENV   ADV_COMFORT ADV_SAFETY ADV_RELIABLE ADV_OILP
 Factor 1: "Environmentally aware at any cost":47  No :114   No : 71   No : 93      No : 89     No :211      No :201    No : 25   No :159     No :211    No :192      No : 98
 Factor 2: "Usability and reliability crucial":47  Yes:109   Yes:152   Yes:130      Yes:134     Yes: 12      Yes: 22    Yes:198   Yes: 64     Yes: 12    Yes: 31      Yes:125
 Factor 3: "Equivalent transition"             :74
 Factor 4: "Transition with only benefits"     :16
 Factor 5: "Early adopters"                    :19
 Factor 6: "Urban liveability"                 :20
```

Figure3: Descriptive statistics results.

4.3. Linear regression

Here is simple and multiple linear regression results.

4.3.1. Simple linear regressions

4.3.1.1. Model 1

Assessing linear relation between EV_PREFEV_Num and DriverKM_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ DriverKM_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.6040 -0.4896 -0.4466  0.5104  0.5534 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept)   1.43235    0.06820  21.003   <2e-16 ***
DriverKM_Num  0.01430    0.01505   0.951    0.343    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5011 on 221 degrees of freedom
Multiple R-squared:  0.004072,	Adjusted R-squared:  -0.0004344 
F-statistic: 0.9036 on 1 and 221 DF,  p-value: 0.3429
```

Figure 4: Simple linear regression - model 1 output

4.3.1.2. Model 2

Assessing linear relation between EV_PREFEV_Num and HHInc_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ HHInc_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.5491 -0.4811 -0.4357  0.5189  0.5643 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.42436    0.07071  20.144   <2e-16 ***
HHInc_Num    0.01134    0.01096   1.035    0.302    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5009 on 221 degrees of freedom
Multiple R-squared:  0.004824,	Adjusted R-squared:  0.0003207 
F-statistic: 1.071 on 1 and 221 DF,  p-value: 0.3018
```

Figure 5: Simple linear regression - model 2 output

4.3.1.3. Model 3

Assessing linear relation between EV_PREFEV_Num and LIM_PRICE_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ LIM_PRICE_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.5634 -0.4540 -0.4540  0.5461  0.5461 

Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept)     1.6728     0.1253  13.351   <2e-16 ***
LIM_PRICE_Num  -0.1094     0.0718  -1.524    0.129    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4995 on 221 degrees of freedom
Multiple R-squared:  0.0104,	Adjusted R-squared:  0.005923 
F-statistic: 2.323 on 1 and 221 DF,  p-value: 0.1289
```

Figure 6: Simple linear regression - model 3 output

4.3.1.4. Model 4

Assessing linear relation between EV_PREFEV_Num and LIM_BATTERY_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ LIM_BATTERY_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.4925 -0.4925 -0.4832  0.5075  0.5169 

Coefficients:
                Estimate Std. Error t value Pr(>|t|)    
(Intercept)     1.473755   0.114945  12.821   <2e-16 ***
LIM_BATTERY_Num 0.009391   0.068660   0.137    0.891    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5021 on 221 degrees of freedom
Multiple R-squared:  8.465e-05,	Adjusted R-squared:  -0.00444 
F-statistic: 0.01871 on 1 and 221 DF,  p-value: 0.8913
```

Figure 7: Simple linear regression - model 4 output

4.3.1.5. Model 5

Assessing linear relation between EV_PREFEV_Num and EV_ENV

```
Call:
lm(formula = EV_PREFEV_Num ~ EV_ENV)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.7305 -0.5036  0.1774  0.4965  0.7234 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.70908    0.12178   5.823 2.02e-08 ***
EV_ENV       0.11350    0.01715   6.616 2.74e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4587 on 221 degrees of freedom
Multiple R-squared:  0.1653,	Adjusted R-squared:  0.1616 
F-statistic: 43.78 on 1 and 221 DF,  p-value: 2.74e-10
```

Figure 8: Simple linear regression - model 5 output

4.3.1.6. Model 6

Assessing linear relation between EV_PREFEV_Num and ADV_OILPRICE_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ ADV_OILPRICE_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.5440 -0.5440 -0.4184  0.4560  0.5816 

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)    
(Intercept)       1.29273    0.11008  11.744   <2e-16 ***
ADV_OILPRICE_Num  0.12563    0.06722   1.869   0.0629 .  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4982 on 221 degrees of freedom
Multiple R-squared:  0.01556,	Adjusted R-squared:  0.01111 
F-statistic: 3.493 on 1 and 221 DF,  p-value: 0.06295
```

Figure 9: Simple linear regression - model 6 output

4.3.1.7. Model 7

Assessing linear relation between EV_PREFEV_Num and DExpEV_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ DExpEV_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.8333 -0.4692 -0.4692  0.5308  0.5308 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   2.1975     0.2880   7.630 6.92e-13 ***
DExpEV_Num   -0.3641     0.1470  -2.477    0.014 *  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4953 on 221 degrees of freedom
Multiple R-squared:  0.02702,	Adjusted R-squared:  0.02262 
F-statistic: 6.137 on 1 and 221 DF,  p-value: 0.01399
```

Figure 10: Simple linear regression - model 7 output

4.3.1.8. Model 8

Assessing linear relation between EV_PREFEV_Num and DExpHYB_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ DExpHYB_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.8261 -0.4500 -0.4500  0.5500  0.5500 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)   2.2022     0.2068  10.651  < 2e-16 ***
DExpHYB_Num  -0.3761     0.1076  -3.494 0.000574 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4888 on 221 degrees of freedom
Multiple R-squared:  0.05236,	Adjusted R-squared:  0.04807 
F-statistic: 12.21 on 1 and 221 DF,  p-value: 0.0005739
```

Figure 11: Simple linear regression - model 8 output

4.3.1.9. Model 9

Assessing linear relation between EV_PREFEV_Num and ExpOEM_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ ExpOEM_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.7381 -0.4309 -0.4309  0.5691  0.5691 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  2.04525    0.15472  13.219  < 2e-16 ***
ExpOEM_Num  -0.30716    0.08348  -3.679 0.000294 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4874 on 221 degrees of freedom
Multiple R-squared:  0.05772,	Adjusted R-squared:  0.05345 
F-statistic: 13.54 on 1 and 221 DF,  p-value: 0.0002939
```

Figure 12: Simple linear regression - model 9 output

4.3.1.10. Model 10

Assessing linear relation between EV_PREFEV_Num and ProStat_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ ProStat_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.6206 -0.4578 -0.4345  0.5422  0.5655 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  1.41129    0.06281  22.471   <2e-16 ***
ProStat_Num  0.02326    0.01595   1.458    0.146    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4997 on 221 degrees of freedom
Multiple R-squared:  0.00953,	Adjusted R-squared:  0.005048 
F-statistic: 2.126 on 1 and 221 DF,  p-value: 0.1462
```

Figure 13: Simple linear regression - model 10 output

4.3.1.11. *Model 11*

Assessing linear relation between EV_PREFEV_Num and Degree_Num

```
Call:
lm(formula = EV_PREFEV_Num ~ Degree_Num)

Residuals:
    Min      1Q  Median      3Q     Max 
-0.7367 -0.4637 -0.1907  0.3998  0.8093 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  0.91763    0.14029   6.541 4.19e-10 ***
Degree_Num   0.13651    0.03263   4.184 4.13e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4834 on 221 degrees of freedom
Multiple R-squared:  0.0734,	Adjusted R-squared:  0.06921 
F-statistic: 17.51 on 1 and 221 DF,  p-value: 4.133e-05
```

Figure 14: Simple linear regression - model 11 output

4.3.2. Multiple linear regression - Model 12

Pearson correlation

```
              EV_PURCHASE     BSI_F2 EV_CONSIDER EV_NEARFUTURE    EV_WORK
EV_PURCHASE     1.0000000 -0.3530415   0.7041890     0.8367493  0.6288613
BSI_F2         -0.3530415  1.0000000  -0.4025772    -0.4342704 -0.4011239
EV_CONSIDER     0.7041890 -0.4025772   1.0000000     0.6533303  0.6532191
EV_NEARFUTURE   0.8367493 -0.4342704   0.6533303     1.0000000  0.5993082
EV_WORK         0.6288613 -0.4011239   0.6532191     0.5993082  1.0000000
EV_ABPURCHASE   0.3869477 -0.3428864   0.3837199     0.3503245  0.2798668
              EV_ABPURCHASE
EV_PURCHASE       0.3869477
BSI_F2           -0.3428864
EV_CONSIDER       0.3837199
EV_NEARFUTURE     0.3503245
EV_WORK           0.2798668
EV_ABPURCHASE     1.0000000
```

Figure 15: Multiple linear regression - model 12 Pearson correlation output

We can also request a matrix with all possible scatterplots:

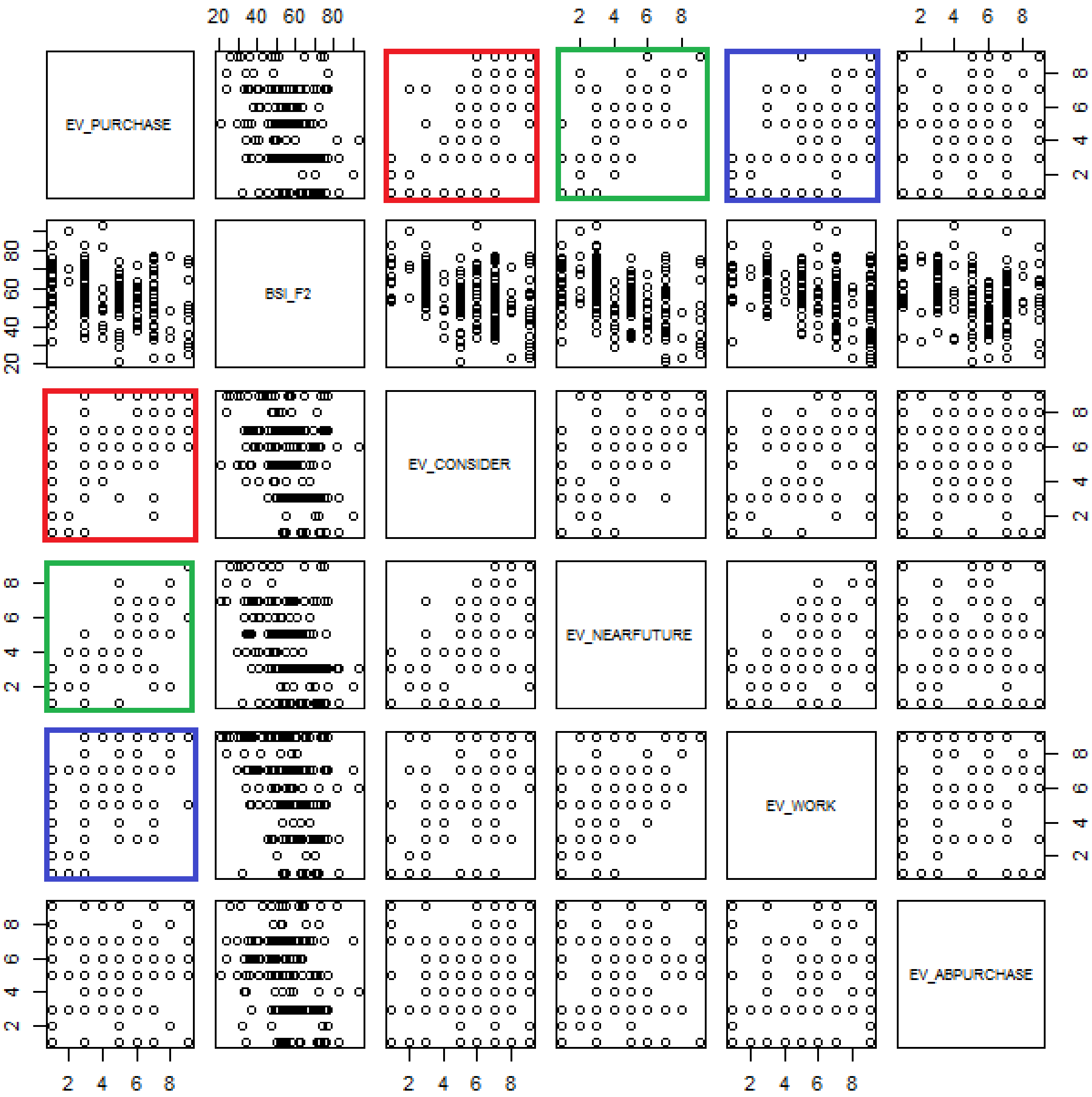


Figure 16: Multiple linear regression - model 12 Pearson correlation scatterplot output

4.3.2.1. Linear relation between variables

Assessing linear relation between EV_PURCHASE, EV_CONSIDER, EV_NEARFUTURE and EV_WORK

```
Call:
lm(formula = Y1 ~ X1)

Residuals:
    Min      1Q  Median      3Q     Max 
-2.5736 -0.4813  0.0453  0.2687  4.3497 

Coefficients:
                Estimate Std. Error t value Pr(>|t|)    
(Intercept)      0.10362    0.19639   0.528   0.5983    
X1EV_CONSIDER    0.21716    0.04755   4.567 8.27e-06 ***
X1EV_NEARFUTURE  0.64091    0.04804  13.341  < 2e-16 ***
X1EV_WORK        0.09228    0.04063   2.271   0.0241 *  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.074 on 219 degrees of freedom
Multiple R-squared:  0.7493,    Adjusted R-squared:  0.7459 
F-statistic: 218.2 on 3 and 219 DF,  p-value: < 2.2e-16
```

Figure 17: Multiple linear regression - model 12 output

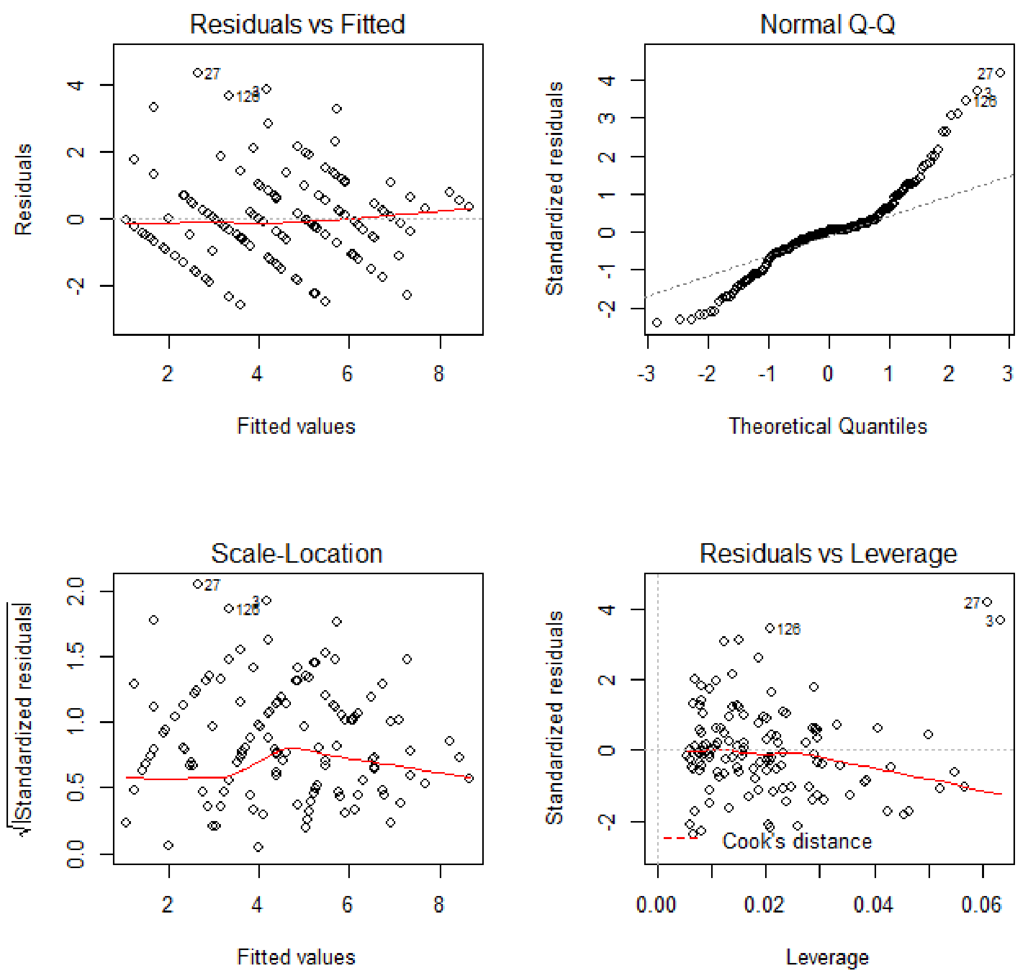


Figure 18: Plot for verification of multiple linear regression - model assumptions

4.3.2.2. Predicted probabilities

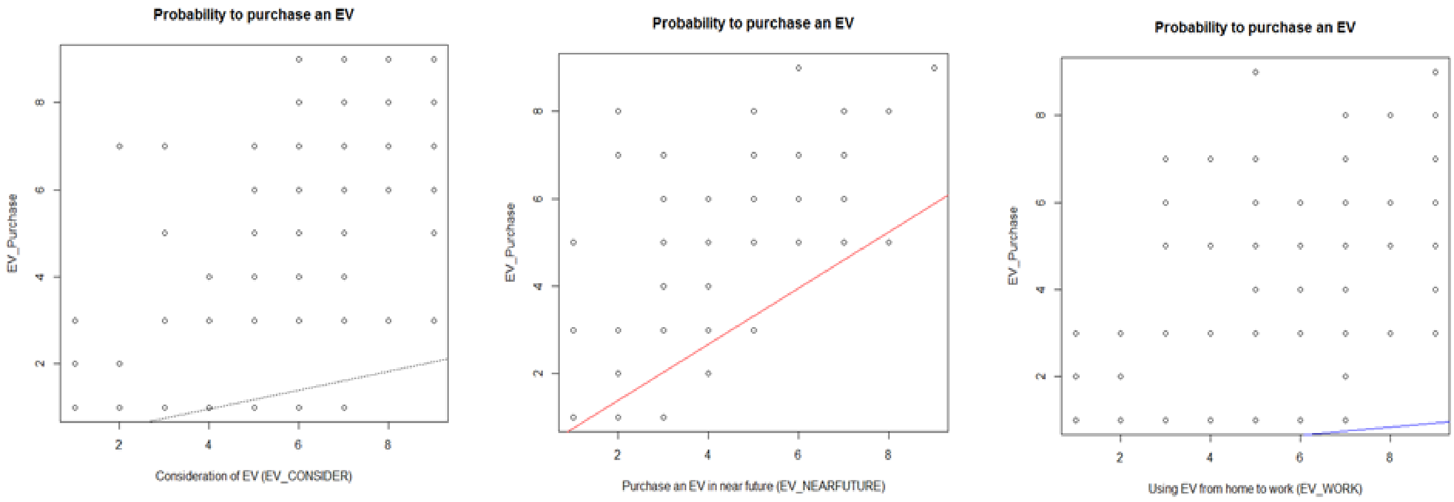


Figure 19: Plot of predicted probabilities to purchase an EV for EV_CONSIDER, EV_NEARFUTURE and EV_WORK variables.

4.3.2.3. ANOVA

```
Analysis of Variance Table

Response: EV_PURCHASE
               Df Sum Sq Mean Sq  F value  Pr(>F)
EV_CONSIDER     1 499.38  499.38 433.2509 < 2e-16 ***
EV_NEARFUTURE   1 249.30  249.30 216.2885 < 2e-16 ***
EV_WORK         1   5.94    5.94   5.1577 0.02412 *
Residuals     219 252.43    1.15
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Figure 20: ANOVA coefficients

Sum of Squares to calculate R-square

```
> SSR1 <- 499.38
> SSR2 <- 249.30
> SSR3 <- 5.94
> SSE <- 252.43
> SSTot <- SSR1 + SSR2 + SSR3 + SSE
>
> SSR1 / SSTot
[1] 0.495884
> SSR2 / SSTot
[1] 0.2475547
> SSR3 / SSTot
[1] 0.005898416
> (SSR1 + SSR2 + SSR3) / SSTot
[1] 0.7493372
```

Figure 21: Calculation of R-square from the sum of squares

4.3.2.4. Checking the interactions between variables by including an interaction effect in the model 12

```
Call:
lm(formula = EV_PURCHASE ~ EV_CONSIDER * EV_NEARFUTURE * EV_WORK)

Residuals:
    Min      1Q  Median      3Q     Max 
-2.5774 -0.5035  0.0214  0.2232  4.1896 

Coefficients:
                                    Estimate Std. Error t value Pr(>|t|)  
(Intercept)                        0.3616096  0.6997022   0.517   0.6058  
EV_CONSIDER                        0.0632934  0.1712581   0.370   0.7121  
EV_NEARFUTURE                      0.4361184  0.2588820   1.685   0.0935 .
EV_WORK                            0.2986133  0.1452321   2.056   0.0410 *
EV_CONSIDER:EV_NEARFUTURE          0.0664960  0.0476874   1.394   0.1646  
EV_CONSIDER:EV_WORK               -0.0158649  0.0260232  -0.610   0.5427  
EV_NEARFUTURE:EV_WORK             -0.0342833  0.0412796  -0.831   0.4072  
EV_CONSIDER:EV_NEARFUTURE:EV_WORK  0.0001517  0.0062772   0.024   0.9807  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.063 on 215 degrees of freedom
Multiple R-squared:  0.7586,    Adjusted R-squared:  0.7507 
F-statistic:  96.5 on 7 and 215 DF,  p-value: < 2.2e-16
```

Figure 22: Multiple linear regression model 12 including interaction effects between variables

4.4. Logit and probit models

4.4.1. Logit model

```
Call:
glm(formula = Y1 ~ X1, family = binomial(link = "logit"))

Deviance Residuals:
     Min        1Q    Median        3Q       Max
-2.40103  -0.73622  -0.00006   0.66232   2.17470

Coefficients:
                      Estimate Std. Error z value Pr(>|z|)
(Intercept)          15.726716 939.796398   0.017  0.98665
X1Degree_Num          0.478339   0.202013   2.368  0.01789 *
X1ProStat_Num         0.218904   0.089188   2.454  0.01411 *
X1DExpEV_Num         -0.948929   0.989004  -0.959  0.33732
X1ExpOEM_Num         -1.644148   0.576181  -2.854  0.00432 **
X1EV_ENV              0.600201   0.148721   4.036 5.44e-05 ***
X1ADV_ENV_Num        -0.455315   0.750906  -0.606  0.54428
X1FACTOR2            -0.003976   0.001674  -2.375  0.01753 *
X1FACTOR3            -0.004214   0.003252  -1.296  0.19506
X1FACTOR4             0.002634   0.001827   1.441  0.14947
X1FACTOR5            -0.002997   0.002866  -1.046  0.29569
X1FACTOR6            -0.001992   0.001716  -1.161  0.24554
X1LIM_PRICE_Num      -0.931008   0.454635  -2.048  0.04058 *
X1LIM_DISTANCE_Num   -0.960901   0.423887  -2.267  0.02340 *
X1LIM_BATTERY_Num    -0.088596   0.427803  -0.207  0.83593
X1LIM_RELIABLE_Num -16.552462 939.791225  -0.018  0.98595
X1LIM_SAFETY_Num      0.763010   1.043086   0.731  0.46448
X1ADV_COMFORT_Num     0.553266   0.535891   1.032  0.30187
X1ADV_SAFETY_Num     -0.273888   1.014466  -0.270  0.78717
X1ADV_RELIABLE_Num    0.668574   0.787469   0.849  0.39587
X1ADV_OILPRICE_Num    0.301040   0.404208   0.745  0.45641
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 309.03  on 222  degrees of freedom
Residual deviance: 195.66  on 202  degrees of freedom
AIC: 237.66

Number of Fisher Scoring iterations: 16
```

Figure 23: Logit model output

```
       (Intercept)      X1Degree_Num      X1ProStat_Num       X1DExpEV_Num
      6.761232e+06      1.613392e+00       1.244712e+00       3.871554e-01
      X1ExpOEM_Num          X1EV_ENV      X1ADV_ENV_Num          X1FACTOR2
      1.931771e-01      1.822484e+00       6.342484e-01       9.960321e-01
         X1FACTOR3         X1FACTOR4          X1FACTOR5          X1FACTOR6
      9.957948e-01      1.002638e+00       9.970075e-01       9.980098e-01
   X1LIM_PRICE_Num X1LIM_DISTANCE_Num X1LIM_BATTERY_Num X1LIM_RELIABLE_Num
      3.941561e-01      3.825482e-01       9.152150e-01       6.476753e-08
  X1LIM_SAFETY_Num X1ADV_COMFORT_Num   X1ADV_SAFETY_Num X1ADV_RELIABLE_Num
      2.144722e+00      1.738924e+00       7.604169e-01       1.951453e+00
X1ADV_OILPRICE_Num
      1.351263e+00
```

Figure 24: Logistic odd ratios

4.4.2. Probit model

```
Call:
glm(formula = Y1 ~ X1, family = binomial(link = "probit"))

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.4046  -0.7424   0.0000   0.6732   2.1439

Coefficients:
                      Estimate Std. Error z value Pr(>|z|)
(Intercept)          4.870e+00  2.249e+02   0.022  0.98272
X1Degree_Num         2.933e-01  1.180e-01   2.486  0.01292 *
X1ProStat_Num        1.307e-01  5.190e-02   2.519  0.01177 *
X1DExpEV_Num        -6.018e-01  5.886e-01  -1.022  0.30664
X1ExpOEM_Num        -9.260e-01  3.286e-01  -2.818  0.00484 **
X1EV_ENV             3.503e-01  8.463e-02   4.139 3.49e-05 ***
X1ADV_ENV_Num       -2.507e-01  4.376e-01  -0.573  0.56669
X1FACTOR2           -2.317e-03  9.697e-04  -2.390  0.01686 *
X1FACTOR3           -2.276e-03  1.868e-03  -1.218  0.22324
X1FACTOR4            1.595e-03  1.058e-03   1.507  0.13176
X1FACTOR5           -1.652e-03  1.665e-03  -0.993  0.32091
X1FACTOR6           -1.121e-03  9.884e-04  -1.134  0.25675
X1LIM_PRICE_Num     -5.587e-01  2.627e-01  -2.127  0.03345 *
X1LIM_DISTANCE_Num -5.610e-01  2.448e-01  -2.292  0.02191 *
X1LIM_BATTERY_Num   -6.487e-02  2.475e-01  -0.262  0.79323
X1LIM_RELIABLE_Num -5.480e+00  2.249e+02  -0.024  0.98056
X1LIM_SAFETY_Num     4.367e-01  6.113e-01   0.714  0.47493
X1ADV_COMFORT_Num    3.344e-01  3.092e-01   1.081  0.27956
X1ADV_SAFETY_Num    -1.584e-01  5.808e-01  -0.273  0.78504
X1ADV_RELIABLE_Num   4.248e-01  4.466e-01   0.951  0.34155
X1ADV_OILPRICE_Num   2.150e-01  2.361e-01   0.911  0.36242
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 309.03  on 222  degrees of freedom
Residual deviance: 195.17  on 202  degrees of freedom
AIC: 237.17

Number of Fisher Scoring iterations: 16
```

Figure 25: Probit model coefficients

4.4.3. Regression marginal effects

```
(Intercept)   X1EV_CONSIDER X1EV_NEARFUTURE       X1EV_WORK
 0.10361711      0.21716018      0.64091316      0.09228388
```

Figure 26: The regression marginal effects

4.4.4. Logit model average marginal effects

```
        (Intercept)      X1Degree_Num       X1ProStat_Num        X1DExpEV_Num
       2.2746963901      0.0691864500        0.0316620295       -0.1372521638
       X1ExpOEM_Num          X1EV_ENV       X1ADV_ENV_Num          X1FACTOR2
      -0.2378078849      0.0868124105       -0.0658562501       -0.0005750584
          X1FACTOR3         X1FACTOR4           X1FACTOR5          X1FACTOR6
      -0.0006095138      0.0003809972       -0.0004334842       -0.0002881472
   X1LIM_PRICE_Num X1LIM_DISTANCE_Num  X1LIM_BATTERY_Num X1LIM_RELIABLE_Num
      -0.1346600976     -0.1389836850       -0.0128144813       -2.3941314336
  X1LIM_SAFETY_Num  X1ADV_COMFORT_Num    X1ADV_SAFETY_Num X1ADV_RELIABLE_Num
       0.1103610010      0.0800239033       -0.0396149544        0.0967019418
X1ADV_OILPRICE_Num
       0.0435420566
```

Figure 27: The logit model average marginal effects

4.4.5. Probit model average marginal effects

```
        (Intercept)      X1Degree_Num       X1ProStat_Num        X1DExpEV_Num
       1.1964764603      0.0720543428        0.0321183557       -0.1478282097
       X1ExpOEM_Num          X1EV_ENV       X1ADV_ENV_Num          X1FACTOR2
      -0.2274912685      0.0860593574       -0.0615862547       -0.0005692631
          X1FACTOR3         X1FACTOR4           X1FACTOR5          X1FACTOR6
      -0.0005590331      0.0003917310       -0.0004059147       -0.0002753829
   X1LIM_PRICE_Num X1LIM_DISTANCE_Num  X1LIM_BATTERY_Num X1LIM_RELIABLE_Num
      -0.1372394580     -0.1378199509       -0.0159352731       -1.3461357667
  X1LIM_SAFETY_Num  X1ADV_COMFORT_Num    X1ADV_SAFETY_Num X1ADV_RELIABLE_Num
       0.1072889400      0.0821417224       -0.0389160809        0.1043570110
X1ADV_OILPRICE_Num
       0.0528168257
```

Figure 28: The probit model average marginal effects

4.4.6. Regression predicted probabilities

```
 Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
1.054   2.955   4.192   4.390   5.691   8.657
```

Figure 29: Regression predicted probabilities

4.4.7. Logit model predicted probabilities

```
  Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.0000  0.1938  0.4592  0.4888  0.8081  0.9992
```

Figure 30: Logit model predicted probabilities

4.4.8. Probit model predicted probabilities

```
  Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.0000  0.2006  0.4643  0.4891  0.7987  1.0000
```

Figure 31: Probit model predicted probabilities

4.4.9. Percent correctly predicted values for logit and probit models

```
    pred
true  0  1
   0 94 20
   1 26 83
```

Logit

```
    pred
true  0  1
   0 95 19
   1 25 84
```

Probit

Figure 32: Percent correctly predicted values for logit and probit models

4.4.10. McFadden's Pseudo R-squared

```
0.3684338
```

Figure 33: The McFadden's Pseudo R-squared

4.5. Multinomial Logit Model

```
Call:
multinom(formula = TQM2 ~ HHInc2, data = EVcsv)

Coefficients:
                                          (Intercept)      HHInc2
 Factor 1: Environmentally aware at any cost   2.1384273 -0.11238366
 Factor 2: Usability and reliability crucial   0.8917888 -0.11749108
 Factor 3: Equivalent transition               1.8728941 -0.75783727
 Factor 4: Transition with only benefits       2.3902920 -0.08846092
 Factor 6: Urban liveability                   1.0402053 -0.02386230

Std. Errors:
                                          (Intercept)     HHInc2
 Factor 1: Environmentally aware at any cost   0.7513613 0.10169884
 Factor 2: Usability and reliability crucial   0.8991293 0.12592753
 Factor 3: Equivalent transition               1.4394616 0.37918945
 Factor 4: Transition with only benefits       0.7311275 0.09796282
 Factor 6: Urban liveability                   0.8081312 0.10764519

Residual Deviance: 639.1519
AIC: 659.1519
```

Figure 34: Multinomial logit model coefficients

4.5.1. P - Values for multinomial logit model

```
                                           (Intercept)     HHInc2
 Factor 1: Environmentally aware at any cost  0.004426236 0.26913214
 Factor 2: Usability and reliability crucial  0.321277556 0.35081710
 Factor 3: Equivalent transition              0.193221706 0.04565472
 Factor 4: Transition with only benefits      0.001078051 0.36652319
 Factor 6: Urban liveability                  0.198033727 0.82456648
```

Figure 35: Multinomial P - values

V. DISCUSSION

All the treatments are done with R software. The results presented in the previous chapter are going to be discussed in this part of the research.

5.1. Descriptive statistics

The figure 3 shows the summary of descriptive statistics. The total number of observation is 223 with 120 males and 103 females. The younger respondent is born in 1999 and the order's year of birth is 1943. The majority of respondents have a higher education (about 63%) and only one respondent does not have any degree. 52 (almost 23%) respondents drive annually 10,000 to 15,000 km. The highest number of respondents (62) travel a distance from home to work/study from 10 to 20 km per day. Many respondents use a car as driver (135 respondents which is about 61%). Most importantly, the respondents who have an experience with an EV are only 12 (5%), with hybrid vehicle 23 (10%) and electric bike 42 (19%) among 223 respondents. In this sample, we see that the experience with any electric vehicle is still very low.

The Talbot's Q - method highested value TQM (factor 1 to 6), many persons can transit with only benefits (91 respondents: almost 41%) and are environmentally aware at any cost (61 respondents: almost 27%). The FSFIS variable, which is a standardized factor score of six variables from the questionnaire, also shows people of transition with only benefits (45) and usability and reliability crucial (40). The self-categorization approach (SCAFD variable) shows especially and equally the persons who are environmentally aware at any cost and usability and reliability crucial (47).

Another variable which refers to EV preference shows that only 109 respondents (almost 49%) prefer EV and other 114 respondents (almost 51%) do not. Many said that they are limited by the EV price, the shorter driven distance, and the battery life exactly as we have found in the literature review where these variables limit the purchase and use of EVs. Meanwhile, most of the respondents (198, almost 89%) who would like to buy an EV find that it is an advantage for the environment and that an EV can help in savings of oil prices.

5.2. Linear regression

The calculations are done with a CI at 95%, which means that we considered a p - value less than 5% (p - value less than 0.05). Firstly, the simple linear regression is done, then the multiple linear regression after.

5.2.1. Simple linear regression interpretations

In the simple linear regression, we tried to check possible variables to see which have the relationship with the dependent variable which is EV_PURCHASE (the purchase of an EV). Eleven models are done for the simple linear regressions but at least only 5 models were possible and one model could go either way (possible or not), additional data are required to take a decision. H0 refers to null hypothesis and H1 refers to alternative hypothesis.

Model 1, figure 4:

H0: there is no linear association between EV_PREFEV_Num and DriverKM_Num

H1: there is a linear association between EV_PREFEV_Num and DriverKM_Num

From the regression model results (p-value=0.343), we are not able to reject the null hypothesis in favor of the alternative. There is no linear association between EV preference and the driving distance from home to work. Accepting the null hypothesis is a weak conclusion, thus more evidences must be collected to make a strong conclusion.

Model 2, figure 5:

H0: there is no linear association between EV_PREFEV_Num and HHInc_Num

H1: there is a linear association between EV_PREFEV_Num and HHInc_Num

From the regression model results (p-value=0.302), we are not able to reject the null hypothesis in favor of the alternative. There is no linear association between EV preference and the house hold income.

Model 3, figure 6:

H0: there is no linear association between EV_PREFEV_Num and LIM_PRICE_Num

H1: there is a linear association between EV_PREFEV_Num and LIM_PRICE_Num

From the regression model results (p-value=0.129), we are not able to reject the null hypothesis in favor of the alternative. There is no linear association between EV preference and the EV price. The price of an EV does not affect the preference of an EV

Model 4, figure 7:

H0: there is no linear association between EV_PREFEV_Num and LIM_BATTERY_Num

H1: there is a linear association between EV_PREFEV_Num and LIM_BATTERY_Num

From the regression model results (p-value=0.891), we are not able to reject the null hypothesis in favor of the alternative. There is no linear association between EV preference and the battery limitation.

Model 5, figure 8:

H0: there is no linear association between EV_PREFEV_Num and EV_ENV

H1: there is a linear association between EV_PREFEV_Num and EV_ENV

From the regression model results (p-value=$2.7*10^{-10}$), we reject the null hypothesis in favor of the alternative. There is a linear association between EV preference and the environmental awareness. The model is now:

$$\boxed{E[EV\_PREFEV\_Num] = 0.709 + 0.1135 * EV\_ENV}$$

The “E” before the model means “estimation”. The increase in one unit in EV_ENV increases the EV preference with 0.1135.

Model 6, figure 9:

H0: there is no linear association between EV_PREFEV_Num and ADV_OILPRICE_Num

H1: there is a linear association between EV_PREFEV_Num and ADV_OILPRICE_Num

From the regression model results (p-value=0.0629), the ADV_OILPRICE_Num is at a statistical marginal significance (could go either way). There may be a linear association between EV preference and the oil price, thus more evidence are needed to show clear relation. In a way where there could be relationship, the model could be:

$$\boxed{E[EV\_PREFEV\_Num] = 1.29 + 0.1256 * ADV\_OILPRICE\_Num}$$

The increase in one unit of oil price (in terms of money), increases the EV preference with 0.1256. Therefore, the increase in oil price is a positive factor regarding the preference of the EV. Thus, the more the oil price increases, the more people prefer EV over diesel/ petrol vehicle.

Model 7, figure 10:

H0: there is no linear association between EV_PREFEV_Num and DExpEV_Num

H1: there is a linear association between EV_PREFEV_Num and DExpEV_Num

From the regression model results (p-value=0.014), we reject the null hypothesis in favor of the alternative. There is a linear association between EV preference and the experience with the EV. The model is now:

E[EV_PREFEV_Num] = 2.197 - 0.36 * DExpEV_Num

The experience with an EV has a negative effect on EV preference. This might be due to the higher price of the EV. Thus, purchasing a second EV becomes a challenge to the owner and this is justified by the negative slope in the model. The increase with one unit in EV experience decreases the EV preference with 0.36.

Model 8, figure 11:

H0: there is no linear association between EV_PREFEV_Num and DExpHYB_Num

H1: there is a linear association between EV_PREFEV_Num and DExpHYB_Num

From the regression model results (p-value=0.000574), we reject the null hypothesis in favor of the alternative. There is a linear association between EV preference and the experience with the hybrid vehicle. The model is now:

E[EV_PREFEV_Num] = 2.2 - 0.376 * DExpHYB_Num

Similar to the experience with an EV, the experience with a hybrid vehicle has a negative effect on EV preference. This is also due to the higher price of the hybrid vehicles. Thus, purchasing a second hybrid vehicle becomes a challenge to the owner and this is justified by the negative slope in the model. The increase with one unit in hybrid vehicle experience decreases the EV preference with 0.376.

Model 9, figure 12:

H0: there is no linear association between EV_PREFEV_Num and ExpOEM_Num

H1: there is a linear association between EV_PREFEV_Num and ExpOEM_Num

From the regression model results (p-value=0.000294), we reject the null hypothesis in favor of the alternative. There is a linear association between EV preference and the experience with the electric bike. The model is now:

$$\boxed{E[EV\_PREFEV\_Num] = 2.04 - 0.307 * ExpOEM\_Num}$$

Similar to both experiences with an EV and a hybrid vehicle, the experience with an electrical bike has a negative effect on EV preference. The increase with one unit in electrical bike experience decreases the EV preference with 0.307.

Model 10, figure 13:

H0: there is no linear association between EV_PREFEV_Num and ProStat_Num

H1: there is a linear association between EV_PREFEV_Num and ProStat_Num

From the regression model results (p-value=0.146), we are not able to reject the null hypothesis in favor of the alternative. There is no linear association between EV preference and the professional status.

Model 11, figure 14:

H0: there is no linear association between EV_PREFEV_Num and Degree_Num

H1: there is a linear association between EV_PREFEV_Num and Degree_Num

From the regression model results (p-value=4.13e-05), we reject the null hypothesis in favor of the alternative. There is a linear association between EV preference and the degree (level of studies). The model is now:

$$\boxed{E[EV\_PREFEV\_Num] = 0.917 + 0.136 * Degree\_Num}$$

Having a degree increases the EV preference with 0.136. This is due to the majority of respondents that have a higher education (63%) they might have sufficient information about EV and its benefits to the environment. Like in the research done by Carley S. et al., 2013 where they say that extremely educated people can adopt an EV.

5.2.2. Multiple linear regression - Model 12

As mentioned before, the multiple linear regression uses two or more independent variables. Before doing a multiple linear regression, we calculated Pearson correlation in order to see which variable would be most suited as the best single predictor for EV_PURCHASE. The matrix with Pearson correlation coefficients may get us started. We consider only the correlation of EV_PURCHASE with the 5 other numerical variables (BSI_F2, EV_CONSIDER, EV_NEARFUTURE, EV_WORK, EV_ABPURCHASE): other variables in X1 (independent variables) were removed from the model, one by one first the variable showing higher p-value until to the variable with less p-value but greater than alpha: 0.05. This process continues till we get the final model.

The matrix with all possible scatterplots (figure 16) can also show the correlations. From both methods, it is clear that EV_CONSIDER, EV_NEARFUTURE and EV_WORK have the highest correlation with EV_PURCHASE (the correlations are highly positive, indeed it makes sense that more environment consideration, buying the EV in the near future and distance from home to work increase the chance to purchase the EV). We will therefore look at the relation between those 3 variables and EV_PURCHASE in more detail. The variables BSI_F2 and EV_ABPURCHASE show very low correlation with EV_PURCHASE and thus are removed from the model.

Figure 17 shows the multiple linear regression for the model 12 output but this is not enough to take a decision and write the final model. There are three assumptions underlying linear regression:

1. Linearity, i.e. there is indeed a linear relation between the predictor and (the mean of) the response variable.

2. Homoscedasticity: the variance of the response should be the same across the range of the predictor.

3. Normality of the error terms: the error terms should follow a normal distribution with mean zero. Given that our model is explained by a continuous variables, we can only assess the assumptions with the aid of the residuals.

In applying the plot function on the object that contains the results of the linear regression (**Figure 18**) we can say that:

1. Top-left: this is the plot of the residuals versus the fitted values. To aid in the interpretation, a red trend line has been added. Ideally, this trend line should fall on the horizontal reference line at Y = 0. This should be interpreted with some tolerance, as in practice there will always be a little deviation (more near the ends of the X-range). Potentially outlying observations are indicated with their row number (here: 3, 27, 126) in the dataset (EV).

2. Top-right: this plot is the normal QQ-plot to assess the normality of the data. In this case, the standardized residuals are used to assess the normality. There are some deviations in the tails, which is normal for the data from a questionnaire.

3. Bottom-left: in this plot, the square root of the absolute values of the standardized residuals is plotted against the fitted values. This plot may be useful in some situations where there is doubt about the assumption of homoscedasticity.

4. Bottom-right: in this plot, the standardized residuals are plotted against the leverage values, which are a measure of how influential each observation was in the fitting of the regression model due to its predictor values. We will focus mostly on the first two plots which show the all the assumptions are fulfilled.

Interpretation of the additive the model results

The output contains the following elements:

1. A reminder of how the model was fit

2. A summary of the distribution of the residuals

3. A table for the model coefficients. From left to right: the estimated value of the coefficient (with its estimated standard error) and the corresponding t-statistic and p-value (calculated from a t-distribution with n-4 = 219 degrees of freedom, as 4 coefficients have been estimated). With a $p < 0.05$ in all cases (p-value = $8.27*10^{-6}$ for EV_CONSIDER, p-value < $2*10^{-16}$ for EV_NEARFUTURE and p-value = 0.0241 for EV_WORK), we can certainly reject H0 ($\beta 0$ =

0; H0: β1 = 0; H0: β2 = 0 and H0: β3 = 0), in favor of their respective alternatives. Even though the p-value for the intercept (p-value = 0.598), the intercept cannot be removed from the model. Moreover, the intercept has no real meaning, thus we will not pay more intention on it.

4. The last part of the output gives an indication of the general model quality. The first line gives the estimate of the residual standard errors with the corresponding degrees of freedom (n - 4 = 219). The second line gives the R^2-value, which reflects that 74.93% (almost 75%) of the variance of EV_PURCHASE has been explained by the model (i.e. by the EV_CONSIDER, EV_NEARFUTURE and EV_WORK variables). It also gives the R^2adj-value, which is based on the R^2-value, but takes into account the number of variables included in the model. The final line gives the results of the F-test corresponding with the hypothesis that all coefficients (accept the intercept) are equal to zero. With $p < 10^{-15}$, we certainly can conclude that there is a linear association between (EV_CONSIDER, EV_NEARFUTURE and EV_WORK) and EV_PURCHASE. The fitted model equation is as follows:

E[EV_PURCHASE] = 0.104 + 0.217 * EV_CONSIDER + 0.641 * EV_NEARFUTURE + 0.092 * EV_WORK

5.2.3. Predicted probabilities

The figure 19 of the predicted probabilities about the multiple linear regression is shows that it is clearly seen that the EV_NEARFUTURE has strong correlation with the EV_PURCHASE variable. The slope of 0.641 means that for one unit increase in EV_NEARFUTURE, the probability to purchase an EV increases with 0.641. The other two variables, EV_CONSIDER and EV_WORK have a weak correlation with EV_PURCHASE with respective slopes of 0.217 and 0.092. Thus, with each increase in one unit of EV_CONSIDER and EV_WORK the probability to purchase an EV increases respectively with 0.217 and 0.092.

5.2.4. ANOVA

Seeing the ANOVA table, where we calculated R-square from the sum of squares (figure 21), the model justify the relationship between EV_PURCHASE, EV_CONSIDER, EV_NEARFUTURE and EV_WORK at 75% which is equal to the R square in the model.

5.2.5. Interaction between variables

The figure 22 indicates that it is clearly seen that there are no interactions between variables of the model EVreg12Int. Thus, the final model to be considered for multiple linear regression is the additive model: E[EV_PURCHASE] = 0.104 + 0.217 * EV_CONSIDER + 0.641 * EV_NEARFUTURE + 0.092 * EV_WORK reminding that the "E" before [EV_PURCHASE], meaning estimate of the variable EV_PURCHASE.

5.2.6. Conclusion of the multiple linear regression model

The data were collected in Wallonia using hard and online questionnaire where 103 female and 120 male answered questions giving their thoughts, ideas and their preferences about the EV. The statistical model was sought for assessing the willingness to purchase an EV, with EV_CONSIDER, EV_NEARFUTURE and EV_WORK as potential predictor variables. A general linear model showed there are no significant interactions effects (on the mean % EV_PURCHASE) between the predictor variables (p-values were higher than 0.05 for each predictor variable). Therefore, the fitted model equation was the additive linear regression:

E[EV_PURCHASE] = 0.104 + 0.217 * EV_CONSIDER + 0.641 * EV_NEARFUTURE + 0.092 * EV_WORK

which means that for every plan to purchase the EV, the probability to purchase an EV, both for male and female, is estimated to increase with 21.72% of consideration ($p = 8.27*10^{-06}$), the intention of buying an EV in the near future has the higher effect on the probability to purchase an EV and increase the probability by 64.10% ($p < 10^{-15}$). Moreover, choosing the EV for work purposes (e.g. for going to work) increases the probability of purchasing an EV with 9.23% (p = 0.024). The fitted model explained 74.59% (the remaining 25.41% are explained by other variables) of the variation in the observed probability to purchase an EV and had a residual standard error of 1.074% probability to purchase an EV.

5.3. Logit and probit models

The logit and probit models are used in order to assess the probability of an event to happen (more luckily to happen or not). The first step is to transform the variables from factors into numeric to make the code run. The figure 23 illustrates the logit model output. It can be explained that more luckily or less luckily, not to report the magnitude at this level. Looking at the results, if people have degree, professional status and are aware of the environment benefit of the EV, they are more luckily to prefer the EV than the normal vehicle using fuel. Whereas, the price of EV, the distance and if people have experienced other electrical transport means such as electrical bike decrease their preference (they are less luckily to prefer) of the EV.

5.3.1. The logit model odds ratios

The logit odds ratios are presented in the figure 24. In this figure, the number higher than zero (positive coefficient) means that the outcome of people who prefer EV (EV_PREFEV_dummy(choice 1)) is more luckily than the number of people who do no prefer the EV (EV_PREFEV_dummy(choice 0); and vice versa for numbers less than one (negative coefficient). One cannot say how much luckily at this level.

5.3.2. Probit model coefficients

The probit model coefficients are shown in figure 25. Probit and logit model give almost the same results (with difference in coefficients) and the interpretation is similar. Also for probit, one can only say how luckily people prefer the EV but not the magnitude.

5.3.3. Regression, logit and probit marginal effects

The results are presented respectfully in figures 26, 27 and 28. The regression marginal effect allow to calculate the logit and probit marginal effects to know how luckily people prefer the EV. For the logit model average marginal effects; to say how much (in %) more luckily. At this level, one can report the magnitude and say how luckily the people prefer the EV. For instance, people having a degree are 6.92% more luckily to prefer EV. Moreover, people with a professional status are 3.17% more luckily to prefer EV. The probit model gives similar results as the logit model with some minor differences on the coefficients but the marginal effects are quiet similar. For example, the people with degree are 7.21% more luckily to prefer EV than people without degree and the same for people with a professional status are 3.21% more luckily to prefer EV than people without professional status.

5.3.4. Regression, logit and probit predicted probabilities

These results are presented respectively in figures 29, 30 and 31. The predicted models show the frequency (in term of mean) of the dependent variable (EV_PREFEV_dummy). We notice almost the similarity between the predicted values of the logit and the probit model.

5.3.5. Percent correctly predicted values for logit and probit models

The figure 32 show the percent correctly predicted value. It is calculated by taking the predicted values from the logit and the probit model, and the values from the data which are called true values. The percent correctly predicted value equals 79.46%, considering the calculations:

(95+83)/(95+83+20+26)

5.3.6. McFadden's Pseudo R-squared

The McFadden's Pseudo R-squared is presented in figure 33. The interpretation of McFadden's pseudo R-squared between 0.2 - 0.4 comes from a book chapter he contributed to: Behavioral Travel Modelling. Edited by David Hensher and Peter Stopher. 1979. McFadden contributed chapter 15 "Quantitative Methods for Analyzing Travel Behavior on individuals: Somme Recent Developments". Discussion of model evaluation (in the context of multinomial logit models) begins on page 306 where he introduces rho-squared (McFadden's pseudo R-squared). McFadden states "While the R-squared index is a more familiar concept to planner who are experienced in OLS, it is not as well behaved as the rho-squared measure for ML estimation. Those unfamiliar with rho-squared should be forewarned that its values tend to be considerably lower than those of the R-squared index etc. For example, values of 0.2 to 0.4 for rho-squared represent excellent fit". So basically, rho-squared can be interpreted like R-squared, but do not expect it to be as big. And values from 0.2-0.4 indicate (in McFadden's words) excellent model fit. The **McFadden's Pseudo R-squared of 0.37** for our model, which is between 0.2 and 0.4, indicate that we have an excellent model.

5.4. Multinomial Logit Model

The multinomial logit model illustrated in figure 34 is explaining the more luckily to happen or not, but using multiple choice answers. The multinom package does not include p-value calculation for the regression coefficients, so we calculate p-values using Wald tests. The p - values are presented in figure 35. Considering the results from the multinomial logit model 1, one- unit increase in the variable. HHInc is associated with the decrease in the log odds of being an equivalent transition vs. early adopter in the amount of 0.76. The relative risk ratio for a one-unit increase in the variable HHInc (household income) is 0.47 for being an equivalent transition vs. early adopter.

VI. CONCLUSION AND RECOMMENDATIONS

The population surveyed for this research know the existence of EVs. A part of the population is interested but they still have the same limitations as found in the literature. They can shift to EVs if the production of electricity used for EVs is good for the environment which mean decarbonized, if the battery life is improved and there are sufficient recharging stations, if they can travel longer distances without changing the battery and if the price of an EV is reduced. But there are also many advantages when an EV is used instead of petrol/diesel vehicles especially for urban commuting. Using an EV does not reject much pollution thus it helps reduce local air pollution, the oil prices and maintenance costs. In addition, an EV is more comfortable than a petrol/diesel vehicle and is as reliable as petrol/diesel vehicles.

Furthermore, the descriptive statistics showed that at least almost 49% prefer to use an EV and 51% do not. We think that the people who do not prefer the use of an EV is because of the limitations mentioned above.

When we were assessing linear regressions using the data from the surveyed population of Wallonia, we found some variables that influence the preference of EV. The simple linear regressions show that at least 5 independent variables have a relationship (positive or negative) with the dependent variable which refers to the preference of an EV Those independent variables are referring to the environment, experience with an electric, hybrid or bike and the one referring to the degree (education). Only one variable is on the statistical marginal significance. This variable is the oil price. Thus, more evidence is required to decide whether or not this variable has a relationship with the variable purchase an EV.

On the other hand, the multiple linear regression model that is made to see the variables that can influence the purchase of an EV has shown that three independent variables has a relationship with the dependent variable referring to purchasing an EV. Those three variables are near future that has a higher predicted probability than two other variables, EV consideration and EV for work.

Moreover, the logit - probit models are also done to assess the probability of the variable referring to preference of an EV to happen. For instance, people having a degree are 6.92%

more luckily to prefer EV. Moreover, people with a professional status are 3.17% more luckily to prefer EV and the percent correctly predicted value equals 79.46%. Then our logit model is excellent because it has a McFadden's Pseudo R-squared of 0.37 which is between 0.2 and 0.4.

Lastly, the multinomial logit model used the HHinc variable which refers to household income, the factor 5 referring to near future variable as a reference and the multinomial TQM variable where the HHInc is associated with the decrease in the log odds of being an equivalent transition vs. early adopter in the amount of 0.76 and the relative risk ratio for a one-unit increase in the variable HHInc (household income) is 0.47 for being an equivalent transition vs. early adopter.

The limitations with the methods used are that sometimes we had to change the variables from factor to numeric or from wide to long for the codes to run. With the used variable we can say that in near future the market of EV will increase if the limitations of EV are lowered, like if they increase EV technologies like battery life, longer distance to travel, lowering the EV price and adding more recharging station.

At last, we would recommend further research and the government should keep stimulating the user for EVs especially in urban transport. We suggest that future improvements and studies in EV technologies can be done so that the EV is used in cities. Also, not only using the electricity for the EV but also using the hydrogen as fuel and other decarbonized fuels for urban transport.

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VIII. APPENDICES

8.1. R coding

This part indicates the programming done in R software.

```
## download package, after change dir in file

library (foreign)

## Importing the data in R

EV <- read.spss("exported.sav", to.data.frame = TRUE) # ignore the warning message, but better asking the profesor


attach(EV) # to not use the dollar sign and make code easier


# Descriptive Analysis

summary(EV)

str(EV)

## ploting gender vs frequency

table(Gender)

table.MF <- table(Gender)

barplot ( table.MF , ylim =c (0 ,130) , ylab = " Frequency ", main = " Number of respondents by gender ")

# Define variables

# To use numeric values (for variables which are factors, we changed them into numeric)

Gender_Num <- as.numeric (Gender)

Degree_Num <- as.numeric (Degree)

ProStat_Num <- as.numeric (ProStat)
```

```
MarStat_Num <- as.numeric (MarStat)

LivSit_Num <- as.numeric (LivSit)

HHInc_Num <- as.numeric (HHInc)

DrivLic_Num <- as.numeric (DrivLic)

DriverKM_Num <- as.numeric (DriverKM)

HWSDist_Num <- as.numeric (HWSDist)

HWSMode_Num <- as.numeric (HWSMode)

HWSFreq_Num <- as.numeric (HWSFreq)

SLFreq_Num <- as.numeric (SLFreq)

DExpEV_Num <- as.numeric (DExpEV)

DExpHYB_Num <- as.numeric (DExpHYB)

ExpOEM_Num <- as.numeric (ExpOEM)

TQM_Num <- as.numeric (TQM)

BSFIS_Num <- as.numeric (BSFIS)

SCAFD_Num <- as.numeric (SCAFD)

EV_PREFEV_Num <- as.numeric (EV_PREFEV)

LIM_PRICE_Num <- as.numeric (LIM_PRICE)

LIM_DISTANCE_Num <- as.numeric (LIM_DISTANCE)

LIM_BATTERY_Num <- as.numeric (LIM_BATTERY)

LIM_RELIABLE_Num <- as.numeric (LIM_RELIABLE)

LIM_SAFETY_Num <- as.numeric (LIM_SAFETY)

ADV_ENV_Num <- as.numeric (ADV_ENV)

ADV_COMFORT_Num <- as.numeric (ADV_COMFORT)

ADV_SAFETY_Num <- as.numeric (ADV_SAFETY)
```

ADV_RELIABLE_Num <- as.numeric (ADV_RELIABLE)

ADV_OILPRICE_Num <- as.numeric (ADV_OILPRICE)

Pearson correlation

EV_Cor <- cbind(Gender_Num, YOB, PC, Degree_Num, ProStat_Num, MarStat_Num, LivSit_Num, HHSize, HHInc_Num, DrivLic_Num, NrCars, DriverKM_Num, HWSDist_Num, HWSMode_Num, HWSFreq_Num, SLFreq_Num, DExpEV_Num, DExpEV_Num, ExpOEM_Num, FACTOR1, FACTOR2, FACTOR3, FACTOR4, FACTOR5, FACTOR6, BSI_F1, BSI_F2, BSI_F3, BSI_F4, BSI_F5, BSI_F6, HBSI_F1, HBSI_F2, HBSI_F3, HBSI_F4, HBSI_F5, HBSI_F6, EV_CONSIDER, EV_NEARFUTURE, EV_PURCHASE, EV_WORK, EV_PEER, EV_PEEREXP, EV_ABPURCHASE, EV_ABDRIVING, EV_ENV, EV_FINANCE, EV_PREFEV_Num, LIM_PRICE_Num, LIM_DISTANCE_Num, LIM_BATTERY_Num, LIM_RELIABLE_Num, LIM_SAFETY_Num, ADV_ENV_Num, ADV_COMFORT_Num, ADV_SAFETY_Num, ADV_RELIABLE_Num, ADV_OILPRICE_Num)

cor(EV_Cor)

EV_Cor <- cbind(DrivLic_Num, Degree_Num, DriverKM_Num, ProStat_Num, HWSDist_Num, Degree_Num, HWSFreq_Num, HHSize, HHInc_Num, NrCars, HWSMode_Num, FACTOR2, FACTOR3, FACTOR6, FACTOR1, FACTOR4, BSI_F1, BSI_F2, BSI_F3, BSI_F6, HBSI_F1, HBSI_F2, HBSI_F3, HBSI_F6, EV_CONSIDER, EV_NEARFUTURE, EV_FINANCE, EV_ABDRIVING, EV_PURCHASE, EV_WORK, EV_PEER, EV_PEEREXP, EV_ABPURCHASE, EV_ENV, EV_PREFEV_Num, LIM_RELIABLE_Num, ADV_ENV_Num, ADV_RELIABLE_Num, ADV_SAFETY_Num, ADV_COMFORT_Num, LIM_PRICE_Num, LIM_DISTANCE_Num, LIM_SAFETY_Num)

cor(EV_Cor)

Regression Models in R

Simple Linear Regressions

Model 1

```
## Assessing linear relation between EV_PREFEV_Num and DriverKM_Num
EVreg1 <- lm(EV_PREFEV_Num ~ DriverKM_Num)
summary (EVreg1)
## H0 : there is no linear association between EV_PREFEV_Num and DriverKM_Num
## H1 : there is a linear association between EV_PREFEV_Num and DriverKM_Num

## Model 2
## Assessing linear relation between EV_PREFEV_Num and HHInc_Num
EVreg2 <- lm(EV_PREFEV_Num ~ HHInc_Num)
summary (EVreg2)
## H0 : there is no linear association between EV_PREFEV_Num and HHInc_Num
## H1 : there is a linear association between EV_PREFEV_Num and HHInc_Num

## Model 3
## Assessing linear relation between EV_PREFEV_Num and LIM_PRICE_Num
EVreg3 <- lm(EV_PREFEV_Num ~ LIM_PRICE_Num)
summary (EVreg3)
## H0 : there is no linear association between EV_PREFEV_Num and LIM_PRICE_Num
## H1 : there is a linear association between EV_PREFEV_Num and LIM_PRICE_Num

## Model 4
## Assessing linear relation between EV_PREFEV_Num and LIM_BATTERY_Num
EVreg4 <- lm(EV_PREFEV_Num ~ LIM_BATTERY_Num)
summary (EVreg4)
```

H0 : there is no linear association between EV_PREFEV_Num and LIM_BATTERY_Num

H1 : there is a linear association between EV_PREFEV_Num and LIM_BATTERY_Num

Model 5

Assessing linear relation between EV_PREFEV_Num and EV_ENV

EVreg5 <- lm(EV_PREFEV_Num ~ EV_ENV)

summary (EVreg5)

H0 : there is no linear association between EV_PREFEV_Num and EV_ENV

H1 : there is a linear association between EV_PREFEV_Num and EV_ENV

Model 6

Assessing linear relation between EV_PREFEV_Num and ADV_OILPRICE_Num

EVreg6 <- lm(EV_PREFEV_Num ~ ADV_OILPRICE_Num)

summary (EVreg6)

H0 : there is no linear association between EV_PREFEV_Num and ADV_OILPRICE_Num

H1 : there is a linear association between EV_PREFEV_Num and ADV_OILPRICE_Num

Model 7

Assessing linear relation between EV_PREFEV_Num and DExpEV_Num

EVreg7 <- lm(EV_PREFEV_Num ~ DExpEV_Num)

summary (EVreg7)

H0 : there is no linear association between EV_PREFEV_Num and DExpEV_Num

H1 : there is a linear association between EV_PREFEV_Num and DExpEV_Num

```r
## Model 8

## Assessing linear relation between EV_PREFEV_Num and DExpHYB_Num

EVreg8 <- lm(EV_PREFEV_Num ~ DExpHYB_Num)

summary (EVreg8)

## H0 : there is no linear association between EV_PREFEV_Num and DExpHYB_Num

## H1 : there is a linear association between EV_PREFEV_Num and DExpHYB_Num


## Model 9

## Assessing linear relation between EV_PREFEV_Num and ExpOEM_Num

EVreg9 <- lm(EV_PREFEV_Num ~ ExpOEM_Num)

summary (EVreg9)

## H0 : there is no linear association between EV_PREFEV_Num and ExpOEM_Num

## H1 : there is a linear association between EV_PREFEV_Num and ExpOEM_Num


## Model 10

## Assessing linear relation between EV_PREFEV_Num and ProStat_Num

EVreg10 <- lm(EV_PREFEV_Num ~ ProStat_Num)

summary (EVreg10)

## H0 : there is no linear association between EV_PREFEV_Num and ProStat_Num

## H1 : there is a linear association between EV_PREFEV_Num and ProStat_Num


## Model 11

## Assessing linear relation between EV_PREFEV_Num and Degree_Num

EVreg11 <- lm(EV_PREFEV_Num ~ Degree_Num)
```

summary (EVreg11)

H0 : there is no linear association between EV_PREFEV_Num and Degree_Num

H1 : there is a linear association between EV_PREFEV_Num and Degree_Num

Multiple linear regression

Model 12

Define variables

EV_Cor <- cbind(EV_PURCHASE, BSI_F2, BSI_F6, HBSI_F2, HBSI_F6, EV_CONSIDER, EV_NEARFUTURE, EV_ABDRIVING, EV_WORK, EV_PEER, EV_PEEREXP, EV_ABPURCHASE, EV_ENV, EV_PREFEV_Num)

cor(EV_Cor)

After elimination of variables with higher p-value

Y1 <- cbind(EV_PURCHASE) # dependent variable

X1 <- cbind(BSI_F2, EV_CONSIDER, EV_NEARFUTURE, EV_WORK, EV_ABPURCHASE) # independent variables

EV_Cor <- cbind(EV_PURCHASE, BSI_F2, EV_CONSIDER, EV_NEARFUTURE, EV_WORK, EV_ABPURCHASE)

cor(EV_Cor)

We can also request a matrix with all possible scatterplots:

par(mfrow =c(2 ,3))

plot(EV[,c(45, 30, 43, 44, 46, 49)])

par(mfrow =c(1 ,1))

```
## The final model
Y1 <- cbind(EV_PURCHASE) # dependent variable
X1 <- cbind(EV_CONSIDER, EV_NEARFUTURE, EV_WORK) # independent variables
## Descriptive statistics
summary(Y1)
summary(X1)
table(Y1) # table gives the frequency of Y1
table(Y1)/sum(table(Y1)) # percent frequency of Y1
## Regression coefficients
EVreg12<- lm(Y1~X1)
summary(EVreg12)

## Apply the plot function on the object that contains the results of the linear regression:
par(mfrow = c(2 ,2))
plot(EVreg12)
par(mfrow = c(1 ,1))

plot ( EV_PURCHASE ~ EV_CONSIDER, data = EV,
xlab ="Consideration of EV (EV_CONSIDER)", ylab ="EV_Purchase",
main ="Probability to purchase an EV")
abline (a =0.104, b =0.217, lty =3, col ="black") # EV_CONSIDER equation

plot ( EV_PURCHASE ~ EV_NEARFUTURE, data = EV,
xlab ="Purchase an EV in near future (EV_NEARFUTURE)", ylab ="EV_Purchase",
```

```
main ="Probability to purchase an EV")

abline (a =0.104, b =0.641, col ="red") # EV_NEARFUTURE equation

plot ( EV_PURCHASE ~ EV_WORK, data = EV,

xlab ="Using EV from home to work (EV_WORK)", ylab ="EV_Purchase",

main ="Probability to purchase an EV")

abline (a =0.104, b =0.092, col ="blue") # EV_WORK equation


## The ANOVA table

EV_an12 <- lm(EV_PURCHASE ~ EV_CONSIDER + EV_NEARFUTURE + EV_WORK)

anova(EV_an12)

## Sum of Square to calculate R-square

SSR1 <- 499.38

SSR2 <- 249.30

SSR3 <- 5.94

SSE <- 252.43

SSTot <- SSR1 + SSR2 + SSR3 + SSE


SSR1 / SSTot

SSR2 / SSTot

SSR3 / SSTot

(SSR1 + SSR2 + SSR3) / SSTot

## Including an interaction effect in the model 12

EVreg12Int <- lm(EV_PURCHASE ~ EV_CONSIDER * EV_NEARFUTURE * EV_WORK)

par(mfrow = c(2 ,2))
```

plot(EVreg12Int)

par(mfrow = c(1 ,1))

Results

summary(EVreg12Int)

##

To assess the probability of an event to happen (more luckly to happen or not), the logit and probit models are used.

Logit and Probit Models in R

Define variables

EV_PREFEV_dummy <- factor(EV_PREFEV, levels=c("No", "Yes"), labels=c(0,1)) # transform from factor to numeric

Y1 <- EV_PREFEV_dummy # dependent variable

X1 <- cbind(Degree_Num, ProStat_Num, DExpEV_Num, ExpOEM_Num, EV_ENV, ADV_ENV_Num, FACTOR2, FACTOR3, FACTOR4, FACTOR5, FACTOR6, LIM_PRICE_Num, LIM_DISTANCE_Num, LIM_BATTERY_Num, LIM_RELIABLE_Num, LIM_SAFETY_Num, ADV_COMFORT_Num, ADV_SAFETY_Num, ADV_RELIABLE_Num, ADV_OILPRICE_Num) # independent variables

Logit model

EV_logit1 <- glm(Y1 ~ X1, family=binomial (link = "logit"))

summary(EV_logit1)

```
## Logit model odds ratios
exp(EV_logit1$coefficients)


## Probit model coefficients
EV_probit1 <- glm(Y1~X1, family=binomial (link="probit"))
summary(EV_probit1)


## Regression marginal effects
coef(EVreg12)


## Logit model average marginal effects: to say how much (in %) more luckily
LogitScalar<- mean(dlogis(predict(EV_logit1, type = "link")))
LogitScalar * coef(EV_logit1)


## Probit model average marginal effects: to say how much (in %) more luckily
ProbitScalar<- mean(dnorm(predict(EV_probit1, type= "link")))
ProbitScalar * coef(EV_probit1)


## Regression predicted probabilities
pEVreg12<-predict(EVreg12)
summary(pEVreg12)



## Logit model predicted probabilities
```

```
pEV_logit1<-predict(EV_logit1, type="response")

summary(pEV_logit1)

## Probit model predicted probabilities

pEV_probit1<- predict(EV_probit1, type="response")

summary(pEV_probit1)

## Percent correctly predicted values

table(true = Y1, pred = round(fitted(EV_probit1)))

table(true = Y1, pred = round(fitted(EV_logit1)))


## McFadden's Pseudo R-squared

EV_probit0 <- update(EV_probit1, formula=Y1 ~ 1)

McFadden <- 1-as.vector(logLik(EV_probit1)/logLik(EV_probit0))

McFadden

################################################################################

## more luckily to happen or not, but using multiple choice answers

## Multinomial Probit and Logit Models in R

## installing the package for logit and probit analysis

install.packages("mlogit")

library(mlogit)

## Convert from spss format to csv format

write.table(read.spss("exported.sav"), file="EVcsv.csv", quote = FALSE, sep = " , ")

EVcsv <- read.csv("EVcsv.csv")

EVcsv

## Exploring the csv file
```

```
head(EVcsv)

## Attach the EVcsv file to make code easier

attach(EVcsv)

str(EVcsv)

summary(EVcsv)

## require packages

require(foreign)

require(nnet)

TQM <- as.factor(TQM)

levels(TQM)

## multinomial logit model

EVcsv$HHInc2 <- as.numeric(HHInc)

EVcsv$TQM2 <- relevel(EVcsv$TQM, ref = " Factor 5: Early adopters " )

mlTQM1 <- multinom(TQM2 ~ HHInc2, data = EVcsv)

summary(mlTQM1)

## The multinom package does not include p-value calculation for the regression coefficients, so we

## calculate p-values using Wald tests (here z-tests)

Z <- summary(mlTQM1)$coefficients/summary(mlTQM1)$standard.errors

Z

## 2-tailed Z test

p <- (1 - pnorm(abs(Z), 0, 1)) * 2

p

## Extract the coefficients from the model and exponentiate

exp(coef(mlTQM1))
```

8.2. Online questionnaire

The questionnaire link was mentioned in the flyers we distributed in the study zone. Here is an example of the flyer:

Figure 36: Example of flyer distributed on the field

8.3. Hard copies

Following is the form of questionnaire hard copies distributed on the field.

Université de Liège KU LEUVEN 1

Cher répondant, chère répondante,

Pour ma thèse, je fais des recherches sur les vues et avis sur les véhicules électriques. Je vous demande s'il vous voulez m'aider en participent à une enquête qui prendra maximum 10 minutes de votre temps. Vos réponses sont traitées d'une façon totalement anonyme.

Je vous remercie beaucoup d'avance pour votre coopération et pour votre temps.

Cordialement,

Marie Reine A. Nishimwe
Etudiante en Master de spécialisation en Gestion Durable de l'Ėnergie
Université de Liège

Avant de poser des questions concernant vos opinions sur les véhicules électriques, on vous demande quelques informations concernant votre situation sociodémographiques.

Q1. Vous êtes ...

- Un homme
- Une femme

Q2. Quelle est votre année de naissance? _______

Q3. Où habitez-vous?

Code postal: ________
Commune: ______________________

Q4. Quel est votre plus haut diplôme (déjà obtenu)?

- Aucun
- Ecole primaire
- Ecole secondaire
- Enseignement supérieur non universitaire
- Enseignement universitaire
- Enseignement post-universitaire

Q5. Quel est votre emploi principal ou votre occupation principale?

- Fonctionnaire
- Employé(e)
- Ouvrier(ère)
- Profession libérale
- Indépendant(e)
- Élève, étudiant(e)
- Femme/homme au foyer
- Sans emploi
- Pensionné(e)
- Autre: ____________________

Q6. Quel est votre état civil?

- Célibataire
- Marié(e)
- Cohabitant(e) légal(e)
- Divorcé(e)
- Veuve/veuf

Q7. Quelle est votre composition de ménage?

- Je vis seul
- Je vis avec mon partenaire
- Je vis avec mon partenaire et des enfants
- Je vis seul(e) avec des enfants
- Je vis avec mes parents dans une famille monoparentale
- Je vis avec mes parents dans une famille de deux parents
- Autre situation familiale

Q8. Combien de personnes composent votre famille, vous y compris? _____

Q9. Quelle est le revenu moyen mensuel net de votre ménage?

- 0-1000 €
- 1000-1500 €
- 1500-2000 €
- 2000-2500 €
- 2500-3000 €
- 3000-3500 €
- 3500-4000 €
- 4000-4500 €
- 4500-5000 €
- Plus de 5000 €
- Je préfère de ne pas spécifier mon revenu

Q10. Avez-vous un permis de conduire (catégorie B)?

- Oui
- Non

Seulement répondez la question suivante si vous avez répondu question Q10 avec "Oui"
Q11. En quelle année avez-vous obtenu votre permis de conduire? ______

Q12. Combien de voitures est-ce que votre ménage a à sa disposition? _______

Q13. Combien de kilomètres parcourez-vous par an comme conducteur d'une voiture?

- 0 km (Vous ne conduisez pas une voiture)
- Moins que 5000 km
- 5000-10000 km
- 10000-15000 km
- 15000-20000 km
- 20000-25000 km
- 25000-30000 km
- 30000-35000 km
- 35000-40000 km
- 40000-45000 km
- 45000-50000 km
- Plus de 50000 km

Q14. Combien de kilomètres habitez-vous de votre domicile à votre travail/école?

- Je ne travaille/étudie pas
- Moins que 5 km
- 5-10 km
- 10-20 km
- 20-50 km
- 50-100 km
- Plus de 100 km

Seulement répondez la question suivante si vous travaillez ou étudiez
Q15. Comment allez-vous le plus souvent au travail ou à l'école? Indiquez le moyen de transport avec lequel vous voyagez la plus grande distance.

- A pied
- Vélo
- Vélomoteur
- Moto
- Voiture (en tant que conducteur)
- Voiture (en tant que passager)
- Train
- Bus (TEC / De Lijn / STIB)
- Tram / métro
- Taxi
- Transport scolaire / transport de la société
- Autre

Seulement répondez la question suivante si vous travaillez ou étudiez

Q16. Combien de fois est-ce que vous vous déplacez de votre domicile à votre travail/école?

- Plusieurs fois par jour
- Une fois par jour
- Plusieurs fois par semaine
- Une fois par semaine
- Moins d'une fois par semaine

Q17. Combien de fois est-ce que vous vous déplacez pour faire du shopping ou des loisirs?

- Plusieurs fois par jour
- Une fois par jour
- Plusieurs fois par semaine
- Une fois par semaine
- Moins qu'une fois par semaine

Avant de poursuivre, il peut être utile de connaître une liste de quelques propriétés de véhicules électriques.

- *Un véhicule électrique ne peut en moyenne rouler 150 km avec une batterie pleine.*
- *Charger la batterie prend entre 6 et 8 heures, mais peut se faire via une prise électrique régulière.*
- *Le prix d'une voiture électrique est plus élevé par rapport à celui d'un véhicule à essence ou à diesel. Néanmoins, il y a différents mesures fiscaux pour stimuler l'utilisation des véhicules électriques, aussi vous ne devez plus jamais remplir avec la gazoline et la maintenance est moins coûteuse.*
- *Une voiture électrique est aussi moins chère en matière d'entretien. En outre, un véhicule électrique ne pollue pas du tout et son moteur n'a pas de bruit.*
- *Le coût en électricité d'un véhicule électrique est de 2,5 €/100km (consommation de 10kWh/100 km avec un prix moyen de 0,25€/kWh) alors que celui du ravitaillement à l'essence est de 7,5 €/100km (consommation de 5L/100km avec un prix moyen de 1,5€/L).*

Q18. Avez-vous une expérience de conduire une voiture électrique? (Un véhicule exclusivement à moteur électrique dont l'énergie de traction est fournie par une batterie installée dans le véhicule à moteur).

- Oui
- Non

Q19. Avez-vous une expérience de conduire des voitures hybrides? (Un véhicule à moteur avec au moins deux moteurs différents. Un qui fonctionne à l'électricité et l'autre à l'essence ou le diesel. Un exemple bien connu est la Toyota Prius).

- Oui
- Non

Q20. Avez-vous l'expérience avec d'autres moyens de transports électriques (par exemple, vélo électrique, ...)?

- Oui
- Non

Dans la partie suivante vous êtes invité à évaluer un certain nombre de déclarations. L'idée est que vous donnez à chaque déclaration votre opinion. S'il vous plaît noter qu'il est très important de répondre à chaque catégorie une seule fois.

Q21. Triez du plus important au moins important et appréciez!
(numérotez 1, 2, 3 etc. depuis le 1er le plus important jusqu'au dernier).
Je trouve important que ...

_______ Un véhicule électrique est meilleur pour l'environnement qu'un véhicule à l'essence/diesel
_______ Je peux facilement conduire partout avec un véhicule électrique
_______ Un véhicule électrique peut parcourir une grande distance
_______ Conduire un véhicule électrique demande beaucoup moins d'entretien
_______ Ma prochaine voiture sera un véhicule électrique
_______ Les véhicules électriques silencieux ont un signal supplémentaire pour avertir les piétons et les cyclistes

Q22. Triez du plus important au moins important et appréciez!
(numérotez 1, 2, 3 etc. depuis le 1er le plus important jusqu'au dernier).
Je trouve important que ...

_______ La génération du courant pour alimenter les véhicules électrique pollue plus que la conduite des véhicules à l'essence/diesel
_______ Un véhicule électrique est aussi fiable qu'un véhicule essence/diesel
_______ Lors de l'obtention d'un permis de conduire, une attention particulière est accordée aux véhicules électriques
_______ Ma deuxième voiture est un véhicule électrique
_______ Le coût de l'achat d'un véhicule électrique neuve est le même que celui d'un véhicule essence/diesel
_______ Conduire un véhicule électrique demande beaucoup moins d'entretien

Q23. Triez du plus important au moins important et appréciez!
(numérotez 1, 2, 3 etc. depuis le 1er le plus important jusqu'au dernier).
Je trouve important que ...

_______ Il existera une assurance séparée ou autre pour des véhicules électriques
_______ Mon deuxième véhicule est un véhicule électrique
_______ Lors de l'obtention d'un permis de conduire, une attention particulière est accordée aux véhicules électriques
_______ Un véhicule électrique demande moins de besoins d'entretien (maintenance) qu'un véhicule à essence/diesel
_______ La génération du courant pour alimenter les véhicules électrique pollue plus que la conduite des véhicules à l'essence/diesel
_______ Un véhicule électrique est plus confortable à conduire qu'un véhicule à essence/diesel (6)

Q24. Triez du plus important au moins important et appréciez!
(numérotez 1, 2, 3 etc. depuis le 1er le plus important jusqu'au dernier).
Je trouve important que ...

_______ Le gouvernement encourage beaucoup l'achat des véhicules électriques
_______ Je ne dois pas adapter mon comportement aux exigences d'un véhicule électrique
_______ Les services de sécurités devraient suivre une formation supplémentaire pour la manipulation des véhicules électriques
_______ La génération du courant pour alimenter les véhicules électrique pollue plus que la conduite des véhicules à l'essence/diesel
_______ Un véhicule électrique est aussi fiable qu'un véhicule essence/diesel
_______ Un véhicule électrique est plus confortable à conduire qu'un véhicule à essence/diesel

Pour les questions suivantes, indiquez jusqu'à quel degré que vous êtes d'accord avec les propositions.
Q25. Évaluez les énoncés suivants:

	Entièrement d'accord (1)	(2)	D'accord (3)	(4)	Neutre (5)	(6)	Pas d'accord (7)	(8)	Entièrement pas d'accord (9)
Un véhicule électrique est meilleur pour l'environnement qu'un véhicule à essence/diesel	○	○	○	○	○	○	○	○	○
Générer le courant nécessaire pour un véhicule électrique est moins polluant que conduire un véhicule à l'essence/diesel	○	○	○	○	○	○	○	○	○
Les véhicules électriques silencieux ont un signal supplémentaire pour avertir les piétons et les cyclistes	○	○	○	○	○	○	○	○	○
Ma deuxième voiture est un véhicule électrique	○	○	○	○	○	○	○	○	○
Le gouvernement stimule beaucoup l'achat des véhicules électriques	○	○	○	○	○	○	○	○	○

Q26. Évaluez les énoncés suivants:

	Entièrement d'accord (1)	(2)	D'accord (3)	(4)	Neutre (5)	(6)	Pas d'accord (7)	(8)	Entièrement pas d'accord (9)
Un véhicule électrique peut être pour moi une alternative parfaite qu'une voiture à essence/diesel	○	○	○	○	○	○	○	○	○
Lors de l'obtention d'un permis de conduire, une attention particulière est accordée aux véhicules électriques	○	○	○	○	○	○	○	○	○
Lorsque vous achetez une véhicule électrique, le coût est le même qu'un véhicule à essence/diesel	○	○	○	○	○	○	○	○	○
Un véhicule électrique nécessite moins d'entretien qu'un véhicule à essence/diesel	○	○	○	○	○	○	○	○	○
Je ne dois pas changer mon comportement aux exigences d'un véhicule électrique	○	○	○	○	○	○	○	○	○

Q27. Évaluez les énoncés suivants:

	Entièrement d'accord (1)	(2)	D'accord (3)	(4)	Neutre (5)	(6)	Pas d'accord (7)	(8)	Entièrement pas d'accord (9)
La technologie des véhicules électriques se trouve entièrement à la pointe, même si ceci veut dire que je vais attendre encore quelques années avant de l'acheter	○	○	○	○	○	○	○	○	○
Les services de sécurités devraient suivre une formation supplémentaire pour la manipulation des véhicules électriques	○	○	○	○	○	○	○	○	○
Il y a beaucoup de stations de recharge pour véhicules électriques	○	○	○	○	○	○	○	○	○
Les véhicules électriques sont particulièrement encouragés dans les milieux urbains	○	○	○	○	○	○	○	○	○

Q28. Évaluez les énoncés suivants:

	Entièrement d'accord (1)	(2)	D'accord (3)	(4)	Neutre (5)	(6)	Pas d'accord (7)	(8)	Entièrement pas d'accord (9)
La charge de la batterie est combinée avec mes déplacements et activités quotidiens	○	○	○	○	○	○	○	○	○
Un véhicule électrique est aussi fiable qu'un véhicule à l'essence/diesel	○	○	○	○	○	○	○	○	○
Un véhicule électrique peut parcourir une grande distance	○	○	○	○	○	○	○	○	○
La voiture électrique doit répondre à des exigences plus strictes en matière de sécurité qu'un véhicule à l'essence/diesel	○	○	○	○	○	○	○	○	○

Q29. Quelle opinion vous correspond le mieux?

○ Je trouve moins important l'aspect financier des choses. Je pense qu'il est très important qu'un véhicule électrique **est meilleur pour l'environnement** qu'un véhicule fonctionnant à l'essence / diesel. En outre, il est pour moi très important que la production d'énergie supplémentaire requise ne soit finalement pas nocive pour l'environnement que la conduite des véhicules à l'essence et le diesel. Je pense aussi qu'il est important que les voitures électriques ne provoquent **pas de pollution** de l'air, et que des stations de recharge devraient être assez disponibles dans de nombreux endroits. J'aime aussi que **la situation ne change pas** fortement par rapport à la situation actuelle. Je ne veux donc pas de changements dans les contrats d'assurance, mais je voudrais recevoir des subventions. Enfin il me semble aussi essentiel que les véhicules électriques ont une sorte de **fonction d'avertissement** pour les cyclistes et les piétons.

○ Je vois tout de suite l'achat d'un véhicule électrique si cela génère des avantages. Si tel est le cas, se faire des petites questions limites n'a pas vraiment d'importance. Par exemple, je trouve très important que mon véhicule est **fiable** et que mon véhicule électrique est une **parfaite alternative**. Pourtant, je suis prêt à **changer mon comportement**. Aussi l'opération du véhicule électrique peut être un peu différente. L'avantage d'un véhicule électrique est le fait que **moins de maintenance** est exigée. Dans les années à venir, je crois qu'il est nécessaire que la communauté passe à une plus grande utilisation de véhicules électriques. À mon avis les exigences de sécurité plus strictes ne sont pas nécessaires.

○ Je suis préoccupé par les restrictions sur un véhicule électrique. Je trouve qu'un véhicule électrique doit être **fiable** et surtout **utile** comme un véhicule à l'essence ou au diesel. Il en résulte, bien entendu, que la durée de vie et la résistance des piles doit être suffisante. Pourtant, je ne pense **pas** que le gouvernement devrait **encourager** une plus grande utilisation de la voiture électrique, et je ne vais pas acheter un véhicule électrique comme un second véhicule. Après avoir obtenu un permis de conduire, je ne pense pas qu'il est important qu'une attention particulière sera accordée au véhicule électrique. Si je devais toujours procéder à l'achat d'un véhicule électrique, il **ne** doit **pas coûter plus cher** que les voitures actuelles.

○ **J'envisage l'achat** d'un véhicule électrique et on peut me décrire comme primo-adoptant. Je pense qu'il est important que ma prochaine voiture soit dotée d'un moteur électrique ou qu'au moins mon **deuxième véhicule** soit remplacé par une voiture électrique. J'espère aussi avoir une grande **facilité d'utilisation**, et j'espère que la sécurité est garantie tant pour moi et mon environnement. Il y a quelques restrictions associées aux véhicules électriques et je n'ai pas de problème avec cela. Je suis prêt à m'**adapter à** ces **restrictions** telles que le temps de charge plus long et la manque de stations de recharge.

○ Je vois définitivement qu'il y a des **avantages** à l'utilisation de véhicules électriques. Néanmoins, je suis préoccupé par **l'aspect pratique** de ceux-ci et le problème de **rechargement**. Donc je pense qu'il est très important qu'il y ait suffisamment de **points de recharge** et que la recharge soit facile à combiner avec mon horaire quotidien. Ce rechargement se fait de préférence le long de l'alimentation régulière. Je crois qu'à un certain moment un véhicule électrique peut être une **alternative parfaite** mais j'attends un peu jusqu'à la technologie plus évoluée. Une fois convaincu, je suis prêt à **accepter quelques limitations**. Je ne suggère pas des exigences plus élevées que de l'équipement actuel sur les véhicules électriques. Des choses comme l'entretien, la sécurité et le confort sont adéquates si elles sont au même niveau comme d'habitude.

○ Je suis convaincu de l'**utilité** des véhicules électriques, mais pas ce n'est pas pour toujours ni pour tout le monde. Je ne crois pas que les **aspects négatifs** actuels peuvent être résolus rapidement, mais pense que ces voitures ont un grand avantage surtout en **milieu urbain**. Néanmoins, j'envisage d'acheter un véhicule électrique comme **deuxième voiture**. Puisque ceux-ci sont parfaitement adaptés pour les plus courts et plus petits déplacements. Pour assurer la sécurité, je pense que la **formation supplémentaire** vaut la peine et que la sécurité du véhicule est un ordre. Je pense moi-même ne pas sauter demain immédiatement pour acheter un véhicule électrique, mais ose en envisager les années à venir.

Q30. Jugez les énoncés suivants.

	Entièrement d'accord (1)	(2)	D'accord (3)	(4)	Neutre (5)	(6)	Pas d'accord (7)	(8)	Entièrement pas d'accord (9)
Je réfléchi à acheter d'un véhicule électrique	❍	❍	❍	❍	❍	❍	❍	❍	❍
Je vais essayer d'acheter un véhicule électrique dans un avenir proche	❍	❍	❍	❍	❍	❍	❍	❍	❍
Je prévois d'acheter un véhicule électrique	❍	❍	❍	❍	❍	❍	❍	❍	❍
Si je devais choisir entre un véhicule électrique et un véhicule ordinaire (par exemple, au travail), j'opté pour le véhicule électrique	❍	❍	❍	❍	❍	❍	❍	❍	❍
Les gens trouvent dans ma région que je devrais acheter un véhicule électrique	❍	❍	❍	❍	❍	❍	❍	❍	❍

Q31. Jugez les énoncés suivants.

	Entièrement d'accord (1)	(2)	D'accord (3)	(4)	Neutre (5)	(6)	Pas d'accord (7)	(8)	Entièrement pas d'accord (9)
Il est attendu de moi que je vais bientôt acheter un véhicule électrique	❍	❍	❍	❍	❍	❍	❍	❍	❍
Si je voulais, je pourrais acheter un véhicule électrique	❍	❍	❍	❍	❍	❍	❍	❍	❍
Si je voulais, je pourrais conduire un véhicule électrique	❍	❍	❍	❍	❍	❍	❍	❍	❍
Si j'achète un véhicule électrique contribuera à un meilleur environnement	❍	❍	❍	❍	❍	❍	❍	❍	❍
Il est impossible pour moi d'acheter un véhicule électrique à cause des facteurs liés au travail ou à ma situation financière	❍	❍	❍	❍	❍	❍	❍	❍	❍

Q32. Si vous devez choisir entre un véhicule électrique et un véhicule ordinaire, est-ce que vous allez opter pour le véhicule électrique?

❍ Oui
❍ Non

Q33. Que ce qui vous empêche le plus pour l'achat d'un véhicule électrique?
Plusieurs réponses possibles

❑ Prix
❑ La courte distance à parcourir (150 km)
❑ Recharge des batteries (4-8h)
❑ Manque de fiabilité
❑ Insécurité

Q34. Pourquoi voudriez-vous acheter un véhicule électrique?
Plusieurs réponses possibles

❑ Environnement
❑ Confort
❑ Sécurité
❑ Fiabilité
❑ Prix élevé d'essence et diesel