TOWARDS A ZERO-CARBON FUTURE. INVESTIGATING THE BARRIERS THAT ARE LIMITING THE ADOPTION OF ELECTRIC VEHICLES IN THE MALTESE ISLANDS.

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# ABSTRACT

As part of the national strategy in promoting sustainable development, the Maltese government is encouraging the adoption of electric vehicles in the Maltese Islands by providing consumers financial incentives. Yet, electric vehicle ownership results to be still very low. This study provides an understanding of the main barriers that are limiting the adoption of electric vehicles, considering also the effectivity of the vehicle's purchase price and running costs on consumers' decisions. The efficacy of current financial incentives is also evaluated to establish if such incentives are determinant in incrementing sales.

Data collection was performed utilising an online questionnaire to individuals of 18 years of age and over, including both consumers who possess a driving licence and those who do not. The questionnaire survey was structured in three sections: the demographic section, Likert Scales and stated choice experiments. The demographic section gives a picture of the demography of the sample population, also providing valuable information in establishing the trends and patterns associated with electric vehicle purchase among different socio-demographic groups in the Maltese society. Likert scales evaluated consumer attitude, perceptions and knowledge towards electric vehicle adoption while stated choice experiments focused on economic factors considered as barriers in the adoption of such vehicles. The data obtained from the questionnaire survey was processed statistically employing crosstabulation, Chi-Square tests and the Multinomial logit model. Crosstabulation evaluated the association between individual socio-demographic variables and electric vehicle purchase, while Chi-Square tests examined the significance of each association. On the other hand, the Multinomial logit model assessed the effectiveness of purchase price, road licence cost, fuel/charging cost and battery replacement cost on the choice of the type of vehicle purchase. Furthermore, the statistical output was also supported by various graphical representations.

This study concludes that purchase price and running costs result to be influential in determining consumers' decision on whether to purchase or otherwise an electric vehicle. Knowledge about such vehicles is still limited among the general public, therefore effective informative campaigns are necessary to increase awareness and reduce perceived risks associated with electric vehicles, which may arise when consumers perform purchase decisions based on heuristics (assumptions based on mental shortcuts). The findings of this research may result helpful when designing policies which aim in promoting an increase in the adoption of electric vehicles in the Maltese Islands, thus, contributing in reaching the target of carbon neutrality.

Keywords:
Electric vehicle adoption, sustainable transport, carbon neutrality, Maltese Islands, financial incentives, climate change

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LIST OF ACRONYMS

EV: Electric vehicle

BEV: Battery Electric Vehicle

PHEV: Plug-in Hybrid Electric Vehicle

HEV: Hybrid Electric Vehicle

ICE: Internal Combustion Engine

MNL: Multinomial Logit Model

CHAPTER 1: INTRODUCTION

1.1. A General Introduction

Electric vehicles (EVs) are not a novel invention but since their introduction in the 19th century (von Brockdorff and Tanti, 2017), they underwent different stages of technological development and advancement (Chan and Wong, 2004; Shariff et al., 2019). The first electric vehicle dates back to the year 1834 when Thomas Davenport manufactured the first electric car in the USA which was able to run utilising a non-rechargeable battery. The limited driving range, between 15 to 30km hindered the penetration of the vehicle in the market (Pollák et al., 2021).

The first electric vehicles were commercialised in 1897, however, vehicles running on petrol started to dominate the market after 1920 because electric vehicles were much slower and had a limited range when compared to petrol vehicles. Moreover, internal combustion engine (ICE) vehicles besides being cheaper (Cowan and Hultén, 1996; Geels, 2004) could be refuelled in a short time, benefitting also from a period when oil prices were still low (Gärling and Thøgersen, 2001). Although it was easier to start battery electric vehicles, this advantage was removed with the invention and introduction of the electric starter motor on internal combustion engine vehicles (Hardman et al., 2015). In the 1990s General Motors tried to revive battery electric vehicles by manufacturing over 1,000 EV-1 battery electric vehicles. This model was short lived due to the poor in-built lead-acid batteries and the introduction of hybrid technology vehicles (Andersen et al., 2009). However, throughout the years, improvements associated with the battery technology, electronics and computers incremented the competitivity of electric vehicles in the market (Grauers et al., 2013), increasing their popularity (von Brockdorff and Tanti, 2017).

1.2. Initiatives adopted by the European Union towards carbon neutrality

In order to participate in the implementation of the United Nations' 2030 Agenda and the Sustainable Development Goals, the European Union (EU) set up a set of policies, known as the European Green Deal, which aims to reduce greenhouse gas emission in the EU by at least 55% by 2030 when compared to 1990 as a step in achieving the final goal of climate neutrality by 2050. The transport sector contributes to about 25% of the total amount of greenhouse gases emitted by the EU and in 2018 road transport contributed to the emissions of 787 Mt of Carbon Dioxide (CO_2) (European Commission, 2019). Apart from Carbon Dioxide emissions, road transport is also a major source of Nitrogen Oxide (NOx) emissions such as Nitrogen Monoxide (NO) and Nitrogen Dioxide (NO_2) which are major atmospheric pollutants in urban areas (Hooftman et al., 2018) contributing to public health issues (Benbrahim-Tallaa et al., 2012). In addition to this, a 90% reduction in transport emissions is necessary in order to achieve climate neutrality by 2050 which is another goal of the EU (European Commission, 2019).

Since the 1990s, the European Union (EU) set up the 'Euro Emissions Standards' directives in order to control vehicle emissions (Mifsud et al., 2021). Although diesel vehicles passed the New European Driving Cycle (NEDC) emissions test, when operating in the real world it was evident that the NOx emissions from such vehicles did not improve so much (Ntziachristos et al., 2016; Franco et al., 2014; Mifsud et al., 2021; Triantafyllopoulos et al., 2019). The European Union tried to overcome this anomaly by replacing the New European Driving Cycle (NEDC) with the Worldwide harmonized Light-duty vehicles Test Procedure (WLTP) and the Real Driving Emissions (RDE) test (Tsokolis et al., 2016) which have become obligatory for passenger vehicles since September 2017 (Triantafyllopoulos et al., 2019). The new procedure is capable of providing more realistic data since driving emissions in the real world are influenced by the driver's driving behaviour, environmental conditions and the vehicle's attributes such as vehicle category, mass and engine capacity (EEA, 2021). In order to further minimise CO_2 emissions from vehicles, the EU replaced the CO_2 target of 130 g/km applicable for the period between 2015 and 2019 with the target of 95 g/km applicable as from the year 2020. Thus, passenger vehicles registered in the year 2020 contributed to 12% less CO_2 emissions per km when compared to 2019 (T&E, 2021).

The 'Fit for 55' package is a set of proposals intended to update EU legislation, which proposes to reduce carbon dioxide emissions from vehicles to 0g CO_2/km by 2035. Therefore, following 2035, the sales of petrol and diesel engines will be banned in the bloc (Graf et al., 2021). As part of the Effort Sharing Regulation (ESR), member states are committed to increase the share of low (less than 50g CO_2 per km) and zero emission vehicles in order to reach carbon neutrality targets. Although increasing the share of electric vehicles on the road is important to reach the target, tailpipe emissions vary among the types of electric vehicles. Hybrid electric vehicles (HEVs) exceed the threshold because they emit an average of 80g CO_2/km, thus plug-in hybrid vehicles (PHEVs) and battery electric vehicles (BEVs) represent the best option in the market to reach the set target (OECD/IEA, 2018). According to the European Environment Agency (2021), an increase in the adoption of electric vehicles such as battery electric vehicles (BEVs) and plug-in hybrid vehicles (PHEVs) was essential in reducing emissions such as CO_2, NOx and particulate matter (pm) in Norway and the Netherlands in the period between 2010 and 2017.

1.3. The local context of the study: the Maltese Islands

1.3.1. Overview of the Maltese Islands

The Maltese Islands is an archipelago in the centre of the Mediterranean covering 316km^2 composed from three major islands: Malta, Gozo and Comino. The islands are inhabited by about 519,562 people (NSO, 2022a) with 480,275 inhabitants in Malta, which is the largest island, and 39,287 inhabitants in the islands of Gozo and Comino (NSO, 2022a). The Maltese Islands achieved independence from the British in 1964 and became a Republic in 1974. In 2004 the Maltese Islands became a member of the European Union and when joining the Euro Zone in 2008, the Maltese Islands adopted the Euro as its currency (Formosa, 2017). The Maltese Islands are subdivided into 68 localities (LAU 2) distributed among 6 districts (LAU 1) illustrated in Figure 1.1. The 6 districts include the Southern Harbour, Northern Harbour, South-Eastern, Western, Northern, Gozo and Comino.

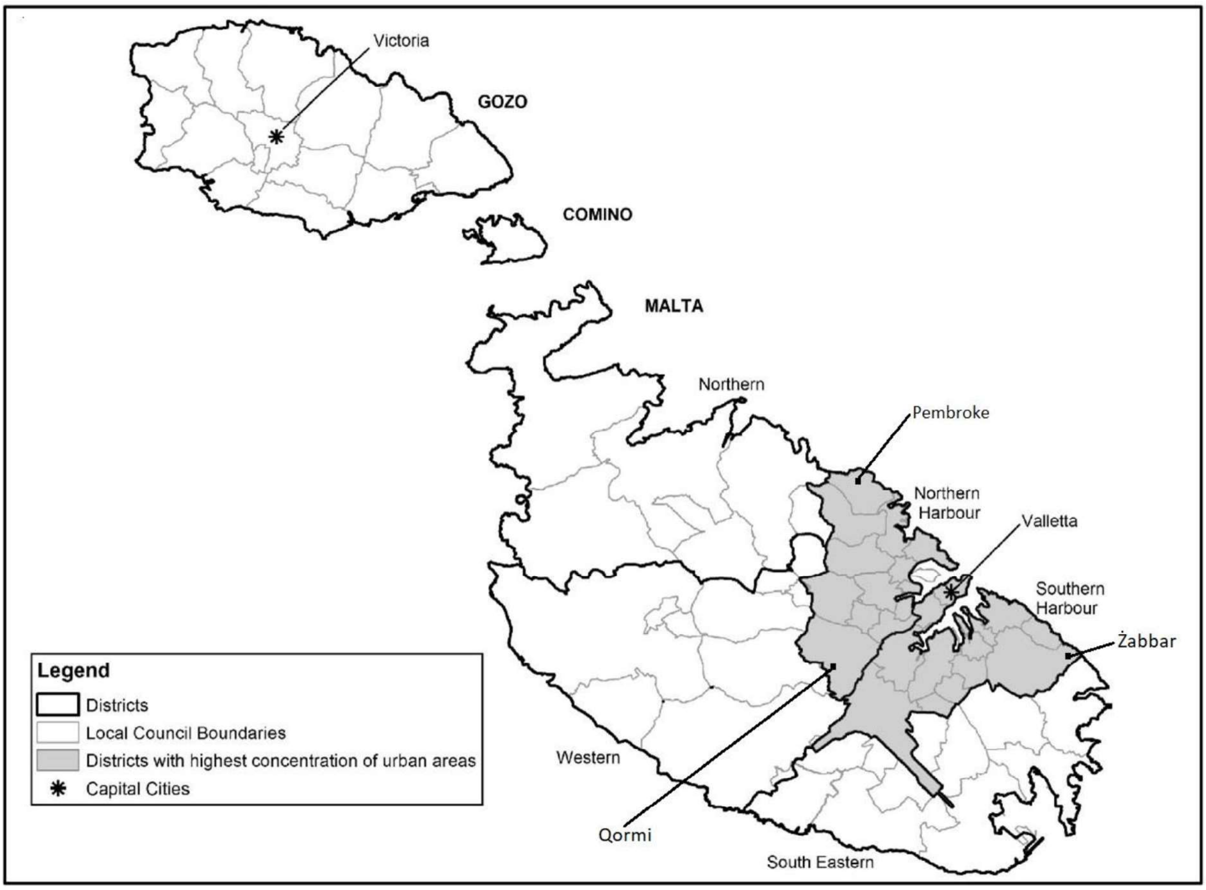

Figure 1.1: The Maltese Islands subdivided into 6 districts
Source: adapted from Mifsud et al. (2017)

The population is considered as being ageing, affected by an increase in life expectancy together with a continuous decline in fertility rate which was 1.3 in 2020 (NSO, 2021a). Almost 19% of the total population at the end of 2017 was composed from individuals of 65 years of age and older (Formosa, 2017). Furthermore, between 2014 and 2020 the 70 – 79 year age group registered the largest growth in Malta and the 90+ age group was the group with the largest growth in Gozo (NSO, 2022b). The Maltese Islands though being the smallest member state in the European Union (EU) have the highest population density in the Union amounting to 1,649 people per km² (NSO, 2022a) which exceeds by far the average population density in the EU which in 2019 was 109 people per km² (Eurostat, 2020).

Rapid urbanisation since the 1970s, due to developments in tourism and the manufacturing industrial sector, modified the country's social and economic structure as well as the natural environment (ERA, 2018). Currently, the western part of Malta is dominated by rural areas while the eastern part is more densely populated, hosting residential areas and industrial activities. The largest agglomeration of buildings includes the harbour region, extending northwards to Pembroke, to Qormi in the centre and southwards to Zabbar. In Gozo, on the other hand, aside from Victoria which is densely populated and characterised for non-agricultural functions, the distinction between urban and rural is less prominent. For planning purposes land use is subdivided into two categories; the Urban Development Zone (DZ) and the Outside Development Zone (ODZ) associated with rural areas (ERA, 2018). Being a car dependent society, an increase in travel throughout the years resulted in the consumption of public land, to make space for more roads and parking (Planning Authority, 2015). Streets within settlements became an extension of the road network (Transport Malta, 2016a) facilitating mobility and access to services, yet, this became a deterrent to safe pedestrianisation, public health and wellbeing (Planning Authority, 2015).

1.3.2. An overview of road transport

Road transport is the main mode of transport in the Maltese Islands, which throughout the years contributed to an increased dependence on private vehicles. By the end of June 2023, the vehicle fleet in the Maltese Islands totalled 432,039, 74.2% of which were passenger vehicles (NSO, 2023a). Private vehicles accounting for 84.3% of the total trips. This mode of transport is mostly prominent among residents in the Northern Harbour and the Northern District and among individuals between 25-44 years of age (NSO, 2022c). Individuals perform most of the trips as drivers, amounting to about 1.25 persons per vehicle (Transport Malta, 2016a). The high percentage of private vehicles and the very low vehicle occupancy contribute to traffic congestion on the roads especially during peak hours. Furthermore, vehicle trip distance increased as a result of limited coordination between land use development and transport planning as well as due to the decentralisation of employment from the harbour region (Transport Malta, 2016b).

1.3.3. An overview of the vehicle stock

As shown in Figure 1.2, at the end of June 2023 (refer to Q2), the number of licensed motor vehicles in the Maltese Islands amounted to 432,039 vehicles, 58.4% (252,197 vehicles) of which run on petrol and 36.2% (156,392 vehicles) run on diesel. Only 3.3% (14,336 vehicles) were electric and plug-in hybrid vehicles (NSO, 2023a). When compared to the first quarter of the year 2023, in the second quarter of the year 2023 there was an increase of 13.3% and 9.1% in the registration of plug-in hybrid (diesel-electric) and plug-in hybrid (petrol-electric) respectively. Out of the total licensed vehicles on the road registered in the second quarter of the year 2023, 5,009 vehicles (67.0%) were newly licensed brand-new vehicles whilst newly licensed second-hand vehicles amounted to 2,467 vehicles (33.0%), (NSO, 2023a).

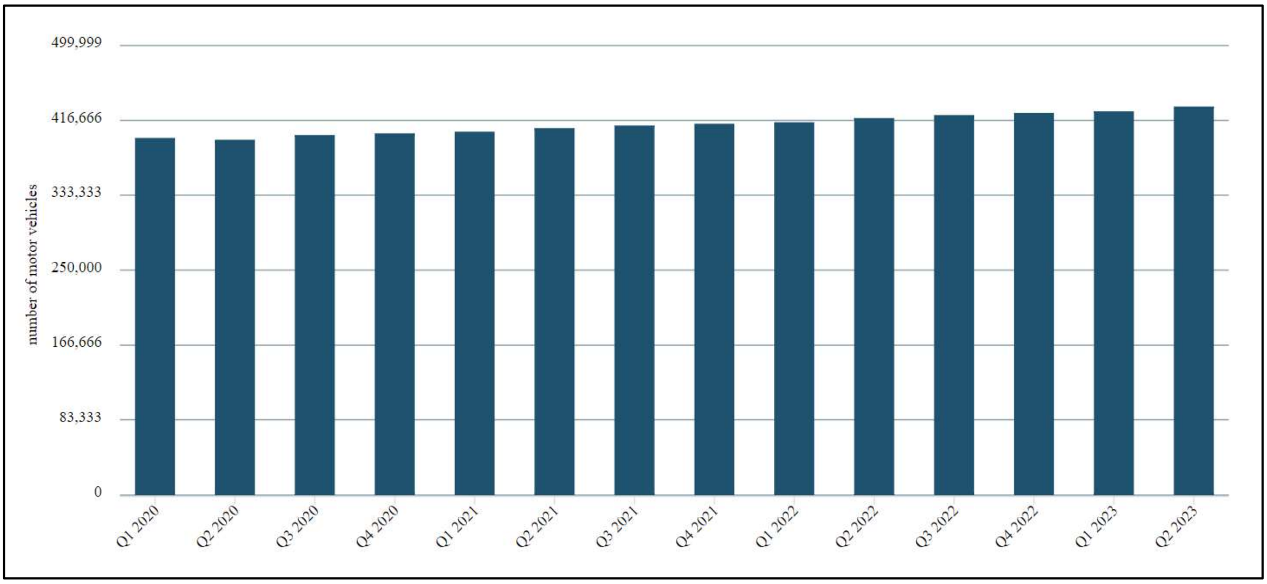

Figure 1.2: Licensed vehicles in the Maltese Islands 2020-2023.
Source: NSO (2023a)

Licensed vehicles in the Maltese Islands have an average age which exceeds that of the European Union (Government of Malta, 2021a), which in 2020 was about 11.8 years old (ACEA, 2022). By the end of 2021 a considerable proportion of the licensed vehicles in the Maltese Islands were between 10 and 19 years old, contributing to a high national average age of licensed passenger vehicle of 14.98 years (Table 1.1). The Southern Harbour district was the district with the oldest licensed passenger vehicles, an average of 16.24 years (Table 1.1). By the end of 2021, 49.6% of the newly licensed second-hand vehicles were between six and ten years old (NSO, 2023b), a decrease when compared to the 56.7% registered in 2020 (NSO, 2022d).

DISTRICT	2016	2017	2018	2019	2020	2021
Southern Harbour	15.26	15.41	15.48	15.61	15.91	16.24
Northern Harbour	13.69	13.76	13.74	13.83	14.28	14.54
South Eastern	14.33	14.47	14.48	14.59	14.87	15.26
Western	13.68	13.80	13.81	13.63	14.30	14.69
Northern	13.14	13.17	13.29	13.27	13.76	14.11
Gozo and Comino	14.59	14.80	15.04	15.08	15.49	15.81
Overall average age	14.03	14.13	14.18	14.26	14.66	14.98

Table 1.1: Average age of passenger vehicle by district between end of years 2016 to 2021.
Source: NSO (2022d; 2023b)

A vehicle stock characterised by a high percentage of old vehicles indicates that most of the licensed vehicles driven in the Maltese Islands do not comply with present emission standards of 95 g/km (T&E, 2021), since the vehicles were manufactured in a period when the acceptable emissions per vehicle were inferior to those established by the current Euro 6 directive (Mifsud et al., 2021). Table 1.2 illustrates emissions of Nitrogen Oxides (NOx), Hydrocarbons (HC), Carbon Monoxide (CO), Particulate Matter (PM) and Carbon Dioxide (CO_2) from vehicles tests performed on Euro 4 vehicles (Ministry for Resources and Rural Affairs, 2012) which as indicated in Table 1.3 were introduced in the year 2005 and sold up till the year 2009, when Euro 5 vehicles were introduced on the market (Drummond and Ekins, 2016).

Vehicle Type	NOx g/km	HC g/km	CO g/km	PM g/km	CO_2 g/km
Diesel	0.210	0.010	0.140	0.022	156.5
Petrol	0.032	0.054	0.427	-	209.8
LPG	0.025	0.039	0.531	-	178.7

Table 1.2: Emissions per vehicle fuel type
Source: Ministry for Resources and Rural Affairs (2012)

Euro standard	Introductory Year
Euro 1	1992
Euro 2	1996
Euro 3	2000
Euro 4	2005
Euro 5	2009
Euro 6	2014

Table 1.3: European emissions (Euro) standard introductory dates
Adapted from Drummond and Ekins (2016)

As illustrated in Figure 1.3, between the years 2010 and 2019 the number of newly licensed new and second-hand passenger cars increased by 38.8%, from 13,605 in 2010 to 18,889 in 2019. During the same time period there was an increase in the number of passenger cars that were scrapped or exported, from 4,008 to 8,425 vehicles. However, when comparing the ratio of newly licensed passenger cars with that of scrapped or exported passenger vehicles, yearly figures are always in favour of newly licensed cars, which was most prominent in 2014 (NSO, 2021b). Table 1.4 illustrates that in both 2020 and 2021 the number of licensed used passenger vehicles (8,609 and 7,627 respectively) surpassed the number of licensed new passenger vehicles (4,602 and 5,250 respectively). This contrast is evident in all six districts, but mostly prominent in the Northern district in 2020 with a difference of 1,033 vehicles and in the Southern Harbour district in 2021 with a difference of 640 vehicles (NSO, 2022d).

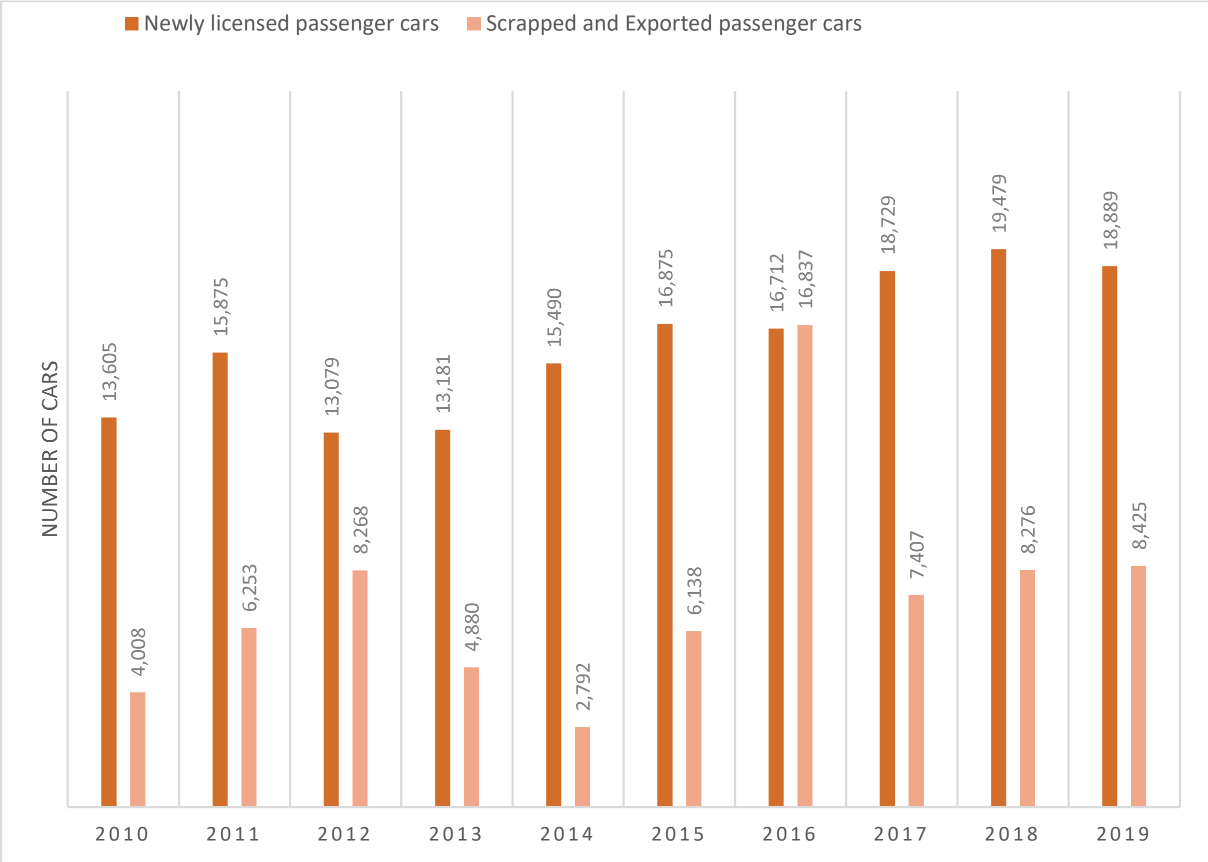

Figure 1.3: Newly licensed and the number of scrapped / exported passenger cars between 2010 - 2019. Source: NSO (2021b).

DISTRICT	Total newly licensed passenger vehicles in 2020	Newly licensed 'NEW' passenger vehicles in 2020	Newly licensed 'USED' passenger vehicles in 2020	Total newly licensed passenger vehicles in 2021	Newly licensed 'NEW' passenger vehicles in 2021	Newly licensed 'USED' passenger vehicles in 2021
Southern harbour	1,956	559	1,397	1,908	634	1,274
Northern harbour	3,803	1,385	2,418	3,713	1,554	2,159
South Eastern	2,069	701	1,368	1,836	607	1,229
Western	1,925	691	1,234	1,906	884	1,022
Northern	2,533	968	1,565	2,599	1,200	1,399
Gozo and Comino	925	298	627	915	371	544
Total	**13,211**	**4,602**	**8,609**	**12,877**	**5,250**	**7,627**

Table 1.4 Share of newly licensed 'new' and 'used' passenger vehicles by district in 2020 and 2021. Source: adapted from NSO (2022d).

1.3.4. Electric vehicle adoption in the Maltese Islands

The increase in passenger vehicles on the road as shown in Figure 1.2 is incrementing issues of noise and air pollution from road transport in the Maltese Islands, both of which have negative consequences on human health and the environment. Although vehicles have become more efficient due to technological improvement, the significant number and age of vehicles on the road in Malta are still contributing to an increased amount of Carbon Dioxide (CO_2), Particulate Matter (PM) and Oxides of Nitrogen (NOx). In the year 2018, 10.5% of all deaths in the Maltese Islands were the result of diseases associated with the respiratory system. In the same year, Malta together with Cyprus registered the highest death rates attributed to asthma (EEA, 2021). Two hundred and thirty of the people that died due to respiratory diseases died prematurely due to particulate matter exposure. On the other hand, less than 1 premature death was attributed to nitrogen dioxide emissions (EEA, 2020). According to a policy document published by the Ministry of the Environment, Climate Change and Planning (Government of Malta, 2021a), in order to reduce road transport emissions, it is necessary to adopt different measures, including the reduction of road-based commuting, the promotion of alternative transport modes and a shift to low or zero emission vehicles as a replacement to the internal combustion.

The EU LIFE (L'Instrument Financier pour l'Environnement) DemoEV Project, an acronym for "Demonstration of the feasibility of electric vehicles towards climate change mitigation" was a project partially funded by the EU (€667,870 out of total sum of €1,888,010) implemented in Malta between September 2011 and December 2014. This LIFE project formed part of the EU action plan to abide with the Kyoto Protocol commitments to reduce carbon dioxide emissions. The project's goal was to introduce and market electric vehicles by demonstrating their cost effectiveness and efficacy in mitigating climate change. Apart from the DemoEV fleet, which totalled 24 electric vehicles, the project catered also for the installation of 90 charging points around the Maltese Islands. Around 130 people participated in the project by utilising the DemoEV vehicles on a daily basis for 8 weeks. When compared to equivalent internal combustion engine vehicles, the project calculated a reduction of 21.6% in greenhouse gas emissions and a net savings of 15 tonnes of CO_2 emissions over 300,000km. Thus, the project not only exposed individuals to an alternative type of vehicle but also increased awareness about the negative impacts of driving an internal combustion engine vehicle (European Commission, 2015). In 2018, as part of an agreement with Transport Malta, CAR2GO Israel launched GoTo Malta, the first car sharing facility (Gadgets, 2018) composed of 150 electric cars. Consumers who availed from the service benefitted from 450 parking slots dedicated to the company's fleet where the vehicles could also be charged (GoTo Malta, 2022). Unfortunately, the company stopped operating in the Maltese Islands by the end of September 2022 due to the long-term low vehicle uptake by Maltese consumers which made the company's operations financially unsustainable, especially during the COVID pandemic period (Times of Malta, 2022).

Different incentives and financial grants were and are still being issued by the Government of Malta in order to encourage the shift from internal combustion engine vehicles to cleaner vehicles such as battery electric vehicles and plug-in hybrid vehicles. The budget for the year 2022 granted individuals that opted to buy an electric vehicle (BEV or PHEV) a maximum sum of €11,000. Moreover, an additional €1,000 was granted if a Maltese resident decided to scrap a conventional vehicle which has been on the road for 10 years or more. Besides the financial grants that reduce the purchase price, electric vehicle adopters are exempted from registration tax and from paying road licence for the first five years after the registration of the vehicle (Caruana, 2021). All financial grants to incentivise electric vehicle adoption granted for the 2022 budget, were renewed in the budget for the year 2023 with the exception of grants on the purchase of plug-in hybrid electric vehicles which when compared to battery electric vehicles release tailpipe emissions (Caruana, 2022). Furthermore, electric vehicle owners do not pay any fee when accessing areas in Valletta's road charging scheme, the Controlled Vehicular Access (CVA) system, as well as benefit from free charging when utilising the three Government Solar Car Ports situated at Ta' Xbiex Marina, the Deep Water Quay at Marsa and Cirkewwa ferry terminal which host a total of 12 charging points (Government of Malta, 2021a; Government of Malta, 2021b).

Despite this, the limited knowledge and skills among mechanics to maintain and repair electric vehicles remains a barrier that needs addressing. Training is required to cater for potential electric hazards and fire risks associated with the in-built high-voltage powertrain (Zhang et al., 2017). However, technical details about such vehicles are often not shared by manufacturers forcing electric vehicle owners to seek help from the factory of origin. This may result in a lengthy service time as well as higher costs (Mo et al., 2022).

The initial success of the electric vehicle market depends on the availability of a regular charging option, either at home or at the workplace (Hardman et al., 2018). Currently, according to Government of Malta (2021b) there are three types of AC chargers in the Maltese Islands: slow single phase AC chargers ($P < 7.4$ kW) present in different housesholds where an individual can charge the vehicle utilising a customary house plug, medium AC three phase chargers (between $7.4 \text{ kW} \leq P \leq 22 \text{ kW}$) and fast three phase chargers ($P > 22$ kW) which consumers can avail from when utilsing the 340 charging points currently present around the Maltese Islands. Furthermore, the Maltese government is planning to increase the total number of medium and fast three phase charging points to about 1,200 by the year 2024 (Caruana, 2022). The launching of the mobile application 'Charge my Ride' allows electric vehicle drivers to locate any available public charging pillar in their vicinity and to follow the vehicle's charging status (Government of Malta, 2021c).

In order to reduce pressure on the power grid, in the year 2021, the Maltese government issued subsidised charging prices during off-peak hours from Monday till Saturday between 00:00 and 05:59 and between 12:00 and 15:59 (see Tables 1.5 and 1.6). The subsidised price is applicable for 24 hours on Sundays, between 00:00 and 23:59 (Government of Malta, 2021c). DC chargers are capable of charging vehicles at a faster rate, but the usage of such chargers is expensive and the large majority of the pre-2020 electric vehicle models are not capable of charging with over 50kW (Government of Malta, 2021b; 2021c). The growth of electric vehicles and an increase in the charging infrastructure is expected to increase pressure on the electricity grid operated by Enemalta (Malta's only electricity supplier). Therefore, plans are underway to set up a second interconnector cable between Malta and Sicily, to import the necessary electricity from the European grid (InterConnect Malta, 2021).

Standard E-Drive Rates for Medium charging pillars	Fast E-Drive Rates for Fast charging pillars
Off peak: €0.1698/unit	Off peak: €0.1798/unit
On peak: €0.1885/unit	On Peak: €0.1985/unit

Table 1.5: Current tariffs when utilising public charging pillars
Source: Government of Malta (2021c).

	Off peak hours tariff (€) (VAT Inclusive)
Residential/Non-residential	Fixed rate of €0.1298/unit
	Peak hours tariff (€) (VAT Inclusive)
Residential	Included in the total current consumption of the household; whereby respective electricity tariff bands apply.
Non-Residential	Fixed rate of €0.1485/unit

Table 1.6: Current tariffs when utilising residential charging
Source: Enemalta (2021)

1.4. Research aim and objectives

Given the current scenario in the Maltese Islands concerning electric vehicle adoption, the author's research aims to evaluate if price and running costs of electric vehicles are important determinants that affect different socio-demographic segments in the Maltese Islands, when deciding to purchase an electric vehicle. The study develops around the following three research questions:

- **Are the price and running costs determinant barriers in the uptake of electric vehicles amongst different socio-demographic segments of society?**

The first research question intends to provide an understanding of how electric vehicles are perceived by different socio-demographic segments in the Maltese society, and how public opinion is influencing the consumers' attitude when purchasing such vehicles. The research question investigates economic and psychological barriers which according to international literature are determinant in influencing decision-making when deciding on whether to purchase or otherwise an electric vehicle. An understanding of the current scenario in the Maltese Islands eventually makes it possible to perform comparisons with trends, patterns and differences outlined by other researchers in the same field area.

- **Are fiscal incentives an effective means to promote the change from internal combustion engine vehicles to electric vehicles?**

Given that the current electric vehicle promotion campaign in the Maltese Islands is based on financial incentives, it is also crucial to determine if such incentives are effective in the long term. Therefore, this research question has the objective to identify what type of financial and non-financial incentives can be effective for a successful campaign. Aside from the identification of incentives, the study also considers the impact of financial disincentives on the consumers' attitudes. A situation where the purchase of ICE vehicles is less attractive when compared to the purchase of electric vehicles can also proof an effective means to increase the number of electric vehicles on the road. Thus, the final objective of the research question is to suggest effective means to convince the Maltese consumers to purchase electric vehicles as an alternative to ICE vehicles.

- **Is knowledge on electric vehicles being marketed in an effective manner to promote a positive attitude towards electric vehicles amongst the general public?**

Knowledge about electric vehicle attributes and current purchase incentives differ among different socio-demographic segments in society. Therefore, a proper marketing strategy is fundamental to increase awareness and consequently participation among the general public. The research question has the goal to evaluate the effectiveness of current marketing campaigns in reaching potential customers, as well as to provide recommendations which may convince consumers, especially the most sceptic ones to perform the change.

1.5. Dissertation structure

This chapter provided a background on initiatives adopted by the European Union to contribute to the attainment of global carbon neutrality. This was followed by an overview of the local situation related to road transport and electric vehicle adoption. Chapter 2 is going to provide a review of international and local literature related to electric vehicle adoption intended to give a background to this study. The literature review considers the different socio-demographic variables associated with the adoption of electric vehicles as well as the different barriers that slow down the adoption. In the Methodology chapter the aim and objectives of the research are outlined, supported by three research questions on which this study evolves. This chapter also incorporates the research approach based on literature and a detailed description of the online questionnaire survey design, utilised to gather primary data. Furthermore, an explanation of the sample size is given together with a description of the ethical review procedure. Chapter 4 analyses statistically and graphically the results obtained from the questionnaire survey. This chapter includes the use of Chi-Square tests which establish the significance of the association between different individual socio-demographic variables and electric vehicle purchase. Moreover, the Multinomial logit model was applied to test the effectiveness of purchase price, fuel cost, road licence cost and battery replacement cost on the adoption of electric vehicles. The outcomes that emerge in chapter 4 are further discussed in chapter 5 where the three research questions are addressed. Finally, this research concludes with chapter 6 in which the main findings are summarised, recommending also policies which can be implemented in the Maltese Islands to promote the sale of electric vehicles. Chapter 6 also considers the difficulties and limitations encountered during the research and indicates possible future research in the field. Three appendices are included at the very end. A copy of the questionnaire survey described in chapter 3 is included in Appendix A. Appendix B includes Crosstabulation exercises and Chi-Square tests while Appendix C comprises the results obtained from the Likert Scale questions in the survey. Reference to the last two appendices was performed throughout the analysis and discussion of the research outcome.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The considerable growth in the number of ICE vehicles has contributed to modifying the structure and function of the urban environment and creating environmental issues such as air pollution and climate change (Sovacool et al., 2018). The transport industry is the second largest carbon emitting industry in the world, accounting for more than 20% of the total global carbon emissions. Road transport by itself accounts for 74% of the total carbon emissions and is the major contributor of carbon emissions released from the transport industry (Ramli et al., 2018). Over time policy makers and stakeholders have explored and supported different forms of sustainable mobility which are more efficient, and which contribute to less carbon dioxide emissions. However, very few efforts have proved to be substantially successful in improving the sustainability of transport (Sovacool et al., 2018).

Electric vehicles are considered as being environmentally friendly vehicles, having a major role in minimising environmental degradation (Dogan and Ozmen, 2019) and in reducing the dependence on petroleum (Breetz and Salon, 2018). Due to their tail-pipe low pollution levels and their high operational efficiency, electric vehicles are considered as being fundamental in the development of the future car industry (Choi et al., 2018). However, the adoption of electric vehicles in various countries is still low (Lu et al., 2022) since the high purchase price represents one of the barriers encountered by consumers which hinders the adoption of electric vehicles (Breetz and Salon, 2018).

The long-term savings from low operating costs are under-estimated by various consumers (Greene, 2010; Krause et al., 2013; Allcott and Wozny, 2014), thus education is considered as a low-cost tool in the promotion of electric vehicles amongst consumers (Breetz and Salon, 2018). However, to implement successful market strategies of electric vehicles, knowledge regarding the characteristics and necessities of the first electric vehicle adopters is fundamental (Plötz et al., 2014).

Various studies related to the promotion of electric vehicles utilised socio-psychological theories such as the Norm-Activation Model (NAM) (Schwartz, 1977), the Theory of Planned

Behaviour (TPB) (Ajzen, 1991) and the Attitude Behaviour Context theory (ABC) (Stern, 1999). However, these theories focus on the consumers' attitude based on behavioural intention without considering the role of human needs when performing purchasing decisions (Cui et al., 2021). Understanding human needs is fundamental to predict purchase motivation, thus it is critical to take into account the needs of drivers in order to encourage consumers to purchase electric vehicles (Akram et al., 2018). The needs of potential electric vehicle consumers are influenced by complex social dynamics such as gender, age, education, employment, income, household size and environmentalism which shape the consumers' preferences (Hidrue et al., 2011; Gallagher and Muehlegger, 2011).

The following section of this chapter and as illustrated in figure 2.1 provides a general background regarding the operational design of hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) which are the three main electric vehicle options available on the market. Then, a general overview of the various socio-demographic variables that influence consumers' decisions related to the purchase of electric vehicles will be given. This section considers variables such as gender, age, educational level, environmental concern, employment and income, household size and vehicle ownership. This is followed by a review of literature dealing with the importance of having an effective marketing strategy to motivate consumers from all demographic segments to purchase electric vehicles. This section also outlines the role of marketing in increasing knowledge and awareness amongst potential electric vehicle buyers. The subsequent part of the chapter describes different forms of incentives which aim at overcoming financial and other barriers encountered by customers who are interested in adopting electric vehicles. Financial incentives minimise the price and total cost of ownership of electric vehicles while non-economic incentives aim in increasing the competitiveness of electric vehicle by improving their convenience over conventional vehicles.

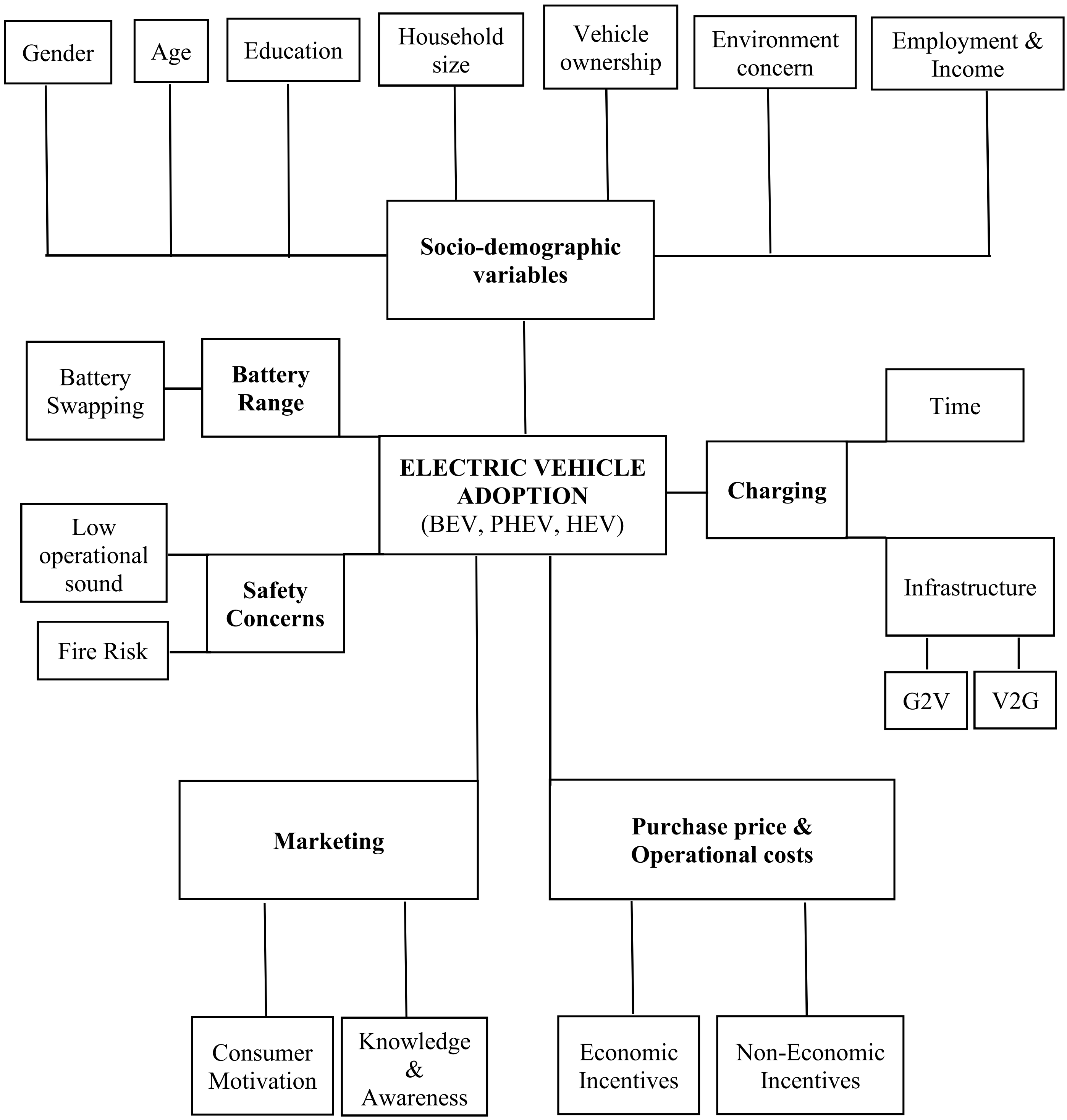

Figure 2.1: An overview of the main aspects associated with electric vehicle adoption covered in the literature review.
Source: Compiled by author

2.2. Electric vehicle options on the market

Hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) are the three types of electric vehicles currently being sold on the market. Although each electric vehicle can operate utilising an in-built battery, batteries are recharged differently. The battery in hybrid electric vehicles (HEVs) can only be charged internally while that of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) can be charged externally (Dudziak et al., 2022).

Besides the in-built nickel cadmium (NiMH) battery pack connected to an electric motor, hybrid electric vehicles (HEVs) are also equipped with an internal combustion engine (Hsu et al., 2013; Hannan et al., 2014). Therefore, hybrid electric vehicles are capable to run on both an internal combustion engine, utilising conventional fuel and/or on the electric power generated by the battery to drive the electric motor. The battery's power can be recharged both while driving and while the vehicle is stationary, utilising a motor powered by an internal combustion engine (Han et al., 2014). Furthermore, by using regenerative braking technology the vehicle's battery is also capable to recharge utilising the braking energy released during deceleration (Han et al., 2014). The distance range covered by the hybrid electric vehicle (HEV) when operating only on its battery depends on the battery energy potential (Hannan et al., 2014).

Plug-in hybrid vehicles (PHEVs), similar to hybrid electric vehicles (HEVs) are equipped with an internal combustion engine and a battery pack, therefore are capable to run on fuel, electricity or a combination of both. Furthermore, similar to hybrid electric vehicles, plug-in hybrid vehicles are also equipped with the regenerative braking technology which contributes to an alternative means to recharge the battery (Poullikkas, 2015). Plug-in hybrid vehicles consume 40% - 60% less fuel and emit 35% - 65% less greenhouse gases when compared to hybrid electric vehicles (Amjad et al., 2010). Moreover, greenhouse gas emissions can be close to zero if renewable energy sources are utilised when charging the vehicle from the electric grid (Hennings et al., 2013; Galus et al., 2010).

The battery electric vehicle (BEVs) operates solely by an electric motor which is powered by an in-built rechargeable Li-ion battery pack that is capable of providing better performance when compared to nickel cadmium (NiMH) battery vehicles (Xu et al., 2013). Contrary to plug-in hybrid vehicles, battery electric vehicles necessitate an on-board battery which supports range as well as the vehicle's different speeds because the vehicle will not be equipped with an internal combustion engine as a backup (Egbue, 2012; Gnann et al., 2018; Farhoodnea et al., 2013). Having a larger rechargeable battery to increase the energy storage contributes to longer charging times and higher costs when compared to the batteries on-board plug-in hybrid vehicles (Poullikkas, 2015). Yet, battery electric vehicles (BEVs) have a higher potential to reduce greenhouse gas emissions when compared to plug-in hybrid vehicles (Tseng et al., 2013), depending on their efficiency and mode of energy generation (Sharma et al., 2012). Fuel cell technology can offer an alternative to batteries in electric vehicles (Duarte et al., 2014) since fuel cells are smaller, less heavy and are recharged in a very short time. Giving that the electric motor is powered as a result of chemical reactions involving hydrogen, the process contributes to limited atmospheric pollution (Gallardo-Lozano et al., 2012; Hooper and Marco, 2014).

2.3. The early electric vehicle adopters

Specific studies, namely Mabit and Fosgerau (2011); Braz da Silva and Moura (2016); Hackbarth and Madlener (2016) and Sierzchula et al. (2014) focused on customers' purchase decision of buying alternative fuel vehicles as a means to reduce air pollution (Bergman et al., 2017). These studies were influenced by methodological individualism where consumers are portrayed as rational acting individuals (Skinner and Rosen, 2016; Banister et al., 2011). Others however have criticised this approach because it disregards the influence of social class structure and politics in the process of decision-making (Dowding and Hindmoor, 1997). Academic automobility studies of transition focus mainly on "manufacturers and regulators, strategies and policies" but neglect "consideration of consumers, early adopters, and related ideas" (Wells and Nieuwenhuis, 2012).

Unlike researchers who were influenced by methodological individualism, Sovacool et al. (2018) did not presume that individuals act rationally and in a predictable manner. Therefore, it is imperative to understand the consumers' socio-demographic perceptions towards both electric vehicles and other forms of mobility, including the consumers' perceptions towards conventional internal combustion engine vehicles. A wider view of the consumer perceptions gives a better understanding of the term '*conventional* use' which goes beyond the vehicle's actual function of being a means of transport (Chen et al., 2016).

2.3.1. The relationship between gender and electric vehicles

According to Sovacool et al. (2018) there is a correlation between gender and car ownership, electric vehicle experience and electric vehicle ownership. In each instance literature identifies electric vehicle adopters as generally males (Hjorthol, 2013; Bjerkan et al., 2016; Plötz et al., 2014, Mohamed et al., 2016; Kim et al., 2014; Carley et al., 2013; Egbue and Long, 2012). Furthermore, men who never owned and do not have an electric vehicle showed more interest in buying electric vehicles when compared to woman (Hidrue et al., 2011; Bjerkan et al., 2016; Plötz et al., 2014; Mohamed et al., 2016; Kim et al., 2014; Jia and Chen, 2021; Vassileva and Campillo, 2017; Egbue and Long, 2012). A different trend was observed when taking into account the environmental benefits of electric vehicles. In Sweden, women give more value to environmental benefits when compared to men (Vassileva and Campillo, 2017). A similar trend was evident in the study performed by Sovacool et al. (2018) in which women were not only inclined to give more importance to the environmental benefits of electric vehicles but also their safety, ease of operation, costs and charging options. When compared to men, women did not consider range as an issue. Yet, women showed less interest in purchasing or testing electric vehicles (Sovacool et al., 2018). However, in the survey performed by Yang et al. (2017) in China, gender was not considered as a determinant factor in delineating new vehicle preferences.

2.3.2. The influence of age on consumer preferences

Age is related to car ownership, which increases with older age groups (Sovacool et al., 2018). Yet, middle-aged people, especially those who have children tend to travel more when compared to younger and older people (Büchs and Schnepf, 2013). Since developed countries are experiencing an ageing population, the number of elderly people above the age of 65 is increasing (Emmerson et al., 2013; Shaheen et al., 2016), resulting in an increase in the number of elderly drivers (Young et al., 2017). Therefore, the elderly group might represent an attractive market for electric vehicles, however in other studies, only a low percentage of individuals that are over 55 years of age (Jia and Chen, 2021; Hidrue et al., 2011) and over 65 years of age (Vassileva and Campillo 2017; Sovacool et al., 2018) owned an electric vehicle or had electric vehicle experience. Moreover, when compared to the younger age groups, the over 65 age group tended to show less interest in electric vehicles or prejudice against them (Bahamonde-Birke and Hanappi, 2016; Sovacool et al., 2018). Contrasting results were presented by Esteves et al. (2021), where middle and older age groups showed more interest in electric vehicles when compared to the 18 – 29 age group.

In the studies performed by Hidrue et al. (2011); Ziegler (2012), Nayum et al. (2016), Plötz et al. (2014), Axsen et al. (2016), Parsons et al. (2014), Sheldon et al. (2017) and Cirillo et al. (2017), electric vehicles are more popular amongst young to middle-aged people. Similar findings were presented by Jia and Chen (2021) in which individuals of 55 years and older showed less interest in hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and BEVs while individuals whose age was 35 years or younger were more interested in non-ICE vehicles. According to various studies there is a higher tendency that younger consumers are more prone to try and adopt novel products and environmentally friendly products because they have a higher inclination to choose innovative products and are more inclined to take risks when compared to older consumers (Laurent and Lambert-Pandraud, 2010). If consumers are exposed to environmental concerns during their life, they will be more sensitive to ecological issues and associated products (Straughan and Roberts, 1999). A new product attracts older people only if the product satisfies their needs and not just because it is popular (Leventhal, 1997). The outcome of the study performed by Zhang et al. (2011) and Shin et al. (2015) contrasts with the above outcomes since it was concluded that BEVs are more likely to be purchased by older consumers. Older customers can afford the initial high cost of BEVs and are less concerned regarding range limitations (Zhang et al., 2011; Shin et al., 2015).

2.3.3. The influence of education on consumer preferences

A common hypothesis in different studies indicates that highly educated individuals, mainly those with postgraduate and undergraduate education are more prone to protect the environment. Universities in particular often cherish a liberal attitude and support the best energy and transport technologies (Sovacool et al., 2012). A positive correlation between carbon emissions and education was identified by Baiocchi et al. (2010), but this positive correlation can only be achieved if other factors are controlled. In other words, higher education leads to more knowledge of environmental problems which will in turn contribute to lower carbon lifestyles. According to research, this trend is also evident in Sweden where early adopters of electric vehicles have a high level of education (Vassileva and Campillo, 2017). Even in Norway, owners of electric vehicles have a high level of education and are "highly motivated" by environmental issues (McKinsey & Company, 2014).

Studies performed by Hjorthol (2013), Bjerkan et al. (2016), Plötz et al. (2014), Simsekoglu (2018), Parsons et al. (2014), Kim et al. (2014) and Jia and Chen (2021) conclude that electric vehicle adopters have a high educational level since education widens the consumers' perspective, facilitating the adoption of innovative products (Tellis et al., 2009). According to Sovacool et al. (2018) education has a significant influence on electric vehicle experience, ownership, and arises interest on such vehicles amongst non-electric vehicle owners. In their research a higher percentage of undergraduate and postgraduate students when compared to secondary school graduates had experience or owned an electric vehicle. Those university graduates who do not own an electric vehicle showed more interest in electric vehicles when compared to secondary school graduates. Moreover, postgraduate students are ready to pay more to purchase their new car when compared to secondary school graduates. A weaker correlation was observed between education and range (battery life), and between education and charging time. Concern on both aspects was shared across all educational levels. On the other hand the study by Zhang et al. (2011) showed opposing results and accordingly well-educated consumers are not willing to purchase battery electric vehicles. This outcome was explained by the fact that educated consumers, who have higher knowledge, are more aware of the disadvantages of electric vehicles, thus opt not to purchase them.

2.3.4. Environmental concerns

Values guide an individual's behaviour and influence how an individual interprets situations and evaluates other people. Furthermore, values determine the perception individuals develop of whether a specific object is important or otherwise (Hahnel et al., 2014). However, the centrality and importance of values in an individual's life differs amongst individuals, giving a self-identify to the person (Verplanken and Holland, 2002). Certain values are associated with pro-environmental behaviour, for example Stern (2020) mentioned that *altruistic* and *biospheric* values are positively correlated with pro-environment behaviour whilst the *egoistic* value is negatively correlated to pro-environment behaviour. If individuals consider the environmental value as being an important value, individuals will show a high concern towards environmental issues, thus will be more inclined to adopt the necessary measures to safeguard the environment (Akram et al., 2018; Liu et al., 2019) and get engaged in pro-environment activities (Zhao et al., 2019). Green purchasing behaviour (Mostafa, 2007) and pro-environment purchasing behaviour (Lee, 2010) are influenced by the extent of environmental concern. High environmental concern encourages consumers to buy pro-environmental products such as electric vehicles (She et al., 2017; Cui et al., 2021) which correspond to the individual's pro-environment values (Verplanken and Holland, 2002).

The relationship between environmental concern and pro-environment products was illustrated in the study performed in the UK by Skippon and Garwood (2011) where environmental protection was considered a motivational factor that encouraged the purchase of electric vehicles. However, Graham-Rowe et al. (2012) reported that battery production and electric consumption put doubts regarding the positive environmental benefits of electric vehicles. Thus, reducing impacts related to battery production and the promotion of green electricity helps in increasing the intentions for electric vehicle adoption (Axsen and Kurani, 2013), especially among consumers with high environmental awareness and high orientation towards technological lifestyles (Axsen et al., 2016). Similar trends were also outlined in studies performed in the Netherlands (Quak et al., 2016) and Germany (Hackbarth and Madlener, 2016) where early battery electric vehicle adopters tend to be more environmentally aware.

According to Degirmenci and Breitner (2018) environmental performance is a stronger predictor to determine purchase intention among consumers when compared to the price and range. Consumers in Denmark and Sweden showed that there is a higher probability that a battery electric vehicle is purchased if the consumer is open to new technologies, believes that a battery electric vehicle expresses environmental awareness and is proud of owning such vehicles (Haustein and Jensen, 2018). Ryghaug and Toftaker (2016) describe early Norwegian adopters as environmentalists and idealists who do not consider additional costs and early problems associated to electric vehicles as barriers. Yet, Figenbaum and Nordbakke (2019) reported that the environmental benefit perception of battery electric vehicles among Norwegians decreased between 2016 and 2018. The respondents neither perceived battery electric vehicles as being an advantage nor a disadvantage for the environment. Most probably this resulted from the fact that electric vehicles in Norway became a regular normal vehicle option for transport (Rotaris et al., 2021).

2.3.5. The relationship between employment, income and electric vehicles

Car ownership is related to employment (Sovacool et al., 2018) which increases both commuting trips and related emissions (Bill et al., 2006). The private sector is the sector which is keen to spend more than €30,000 on the purchase of a vehicle when compared to academics, retired individuals, government officials and unemployed. Electric vehicle interest, experience and ownership peaks among individuals with a high level of education (Esteves et al., 2021; Sovacool et al., 2018) and people with full-time jobs tend to be early adopters of electric vehicles (Morton et al., 2017). On the other hand, in other studies, employment is not considered as being influential in the adoption of electric vehicles (Christidis and Focas, 2019).

A common factor identified by Hjorthol (2013), Bjerkan et al. (2016), Nayum et al. (2016), Axsen et al. (2016), Christidis and Focas (2019), Plötz et al. (2014), and Jia and Chen (2021) is that electric vehicle adopters have higher incomes. Moreover, even individuals who present higher preference for electric vehicles tend to earn a high income (Tanaka et al., 2014; Zhang et al., 2011; Shin et al., 2015). In fact, sensitivity to the purchase price is less among high-income households when compared to low-income households (Hackbarth and Madlener, 2016; Mabit and Fosgerau, 2011; Potoglou and Kanaroglou, 2007).

Contrasting outcomes were obtained by Helveston et al. (2015) since according to their study, high-income consumers are more opposed to HEV, PHEV or BEV when compared to consumers who earn a lower income. According to Bunch et al. (1993), environmental concern decreases as the consumer income increases, resulting in a higher preference for gasoline vehicles among high income consumers.

2.3.6. Household size and electric vehicle ownership

A number of studies reveal that household size is related to electric vehicle ownership, experience and interest (Plötz et al., 2014; Jia and Chen, 2021; Vassileva and Campillo, 2017; Yang et al., 2017). Larger households tend to own more vehicles and are willing to spend more money. Furthermore, large households tend to have more electric vehicle experiences and those large households that do not own electric vehicles are more interested in purchasing these vehicles when compared to smaller households. Most electric vehicle owners live in small to medium sized towns (Plötz et al., 2014) and live in multi-car households, often with children (Hjorthol, 2013; Bjerkan et al., 2016; Peters and Dütschke, 2014; Klöckner et al., 2013; Nayum et al., 2016; Garling and Thogersen, 2001). Also, families with children are more concerned with the negative impacts on the environment and are prone to pay more for environmental products to safeguard their children's future (Laroche et al., 2001). With regard to household size, contradicting results were observed from the literature, since according to some studies, people buying electric vehicles live in large households (Nayum et al., 2016) while a study performed in Sweden showed that people owning electric vehicles are more likely to live in smaller households when compared to those not owning an electric vehicle (Langbroek et al., 2017).

2.3.7. Electric vehicles and number of vehicles per households

In a study performed by Nayum et al. (2013) in Norway, it was concluded that the respondents who owned an electric vehicle, lived in households that owned other vehicles. Only 9.5% of the respondents owned an electric vehicle as their sole vehicle. The large majority of the households owned two or more than two vehicles, 75.7% and 14.9% of the households respectively. The same trend was also observed by Figenbaum and Kolbenstvedt (2013) who performed a similar study in Norway. The outcome of both studies shows clearly that electric vehicles are not considered as an alternative to internal combustion engine vehicles but often considered as an additional vehicle (Nayum et al., 2013; Figenbaum and Kolbenstvedt, 2013). Therefore, multi-car households can be considered as one of the early adopters of electric vehicles (Jakobsson et al., 2016) since households owning more than one vehicle have a higher income (Jong et al., 2004; Dargay, 2002) which helps in overcoming the high purchase price barrier of electric vehicles (Jakobsson et al., 2016).

If the electric vehicle is the only vehicle in the household, drivers often drive less when compared to drivers owning a conventional vehicle. It was speculated that this trend is influenced by electric vehicle limitations namely those associated with range (Nayum et al., 2013). Thus, electric vehicles are introduced in multi-car households in order to perform short daily activities and household members may opt to shift from the use of an internal combustion engine vehicle to an electric vehicle depending on the distance travelled (Jakobsson et al., 2016). On the other hand, an electric vehicle is utilised for most of the trips performed if it is not the only vehicle in the household. Therefore, if the electric vehicle is not a substitute to the conventional vehicle, a multi-car household owning both conventional and an electric vehicle does not contribute in reducing the annual vehicle mileage (Nayum et al., 2013).

High income households tend to make more trips which might exceed the driving range of the electric vehicle. Therefore, owning also a traditional ICE vehicle is a necessity (Jakobsson et al., 2016). Accordingly, in Sweden and Germany, the second car in a two-car household tends to be utilised for regular but short trips. Thus, it is easier to substitute the second car with an electric vehicle. In order to increase the number of battery electric vehicles as first and single cars, long range battery electric vehicles might be necessary (Jakobsson et al., 2016). In an attempt to counteract range anxiety drivers opt for a plug-in hybrid electric vehicle (PHEV) if they want to utilise their vehicle to satisfy all their daily trips (Björnsson and Karlsson, 2017). However, if the use of the first electric vehicle satisfies the household's needs, there is a higher tendency that the second electric vehicle is purchased after a short time (Hamed et al., 2021).

2.4. Charging infrastructure as key to electric vehicle adoption

The electric vehicle's battery capacity restricts the range the vehicle can travel with a single charge. High garage ownership facilitates individuals to perform regular daily charges, but in those countries where garage ownership is low, public charging facilities are necessary (Helmus et al., 2018). Therefore, the presence of high-power charging stations along travel routes is important in order to facilitate long trips (Figenbaum and Kolbenstvedt, 2016; Nicholas and Hall, 2018). It is also necessary to strengthen electricity supply from the power grid to cater for the increased pressure on the power grid (Davidov and Pantoš, 2017). Drivers are not eager to change their driving behaviour but prefer to maintain their current mobility pattern (Philipsen et al., 2015.) According to certain studies, consumers perceive the extra time spent to charge the electric vehicle or the time spent in detours to utilise a charging station as a barrier (Philipsen et al., 2015; Halbey et al., 2015; Egbue, 2012; Davidov and Pantoš, 2017). In fact, in the study performed by Sun et al. (2017), approximately half of the participants were in favour of having a charging station within a five-minute drive.

Standard plug sockets can be utilised to charge an electric vehicle; however, electric vehicles will take a long time to charge (Hardman et al., 2018). Electric vehicle drivers prefer fast charging facilities (Philipsen et al., 2016), especially those who do not have a charging facility at home. Fast charging can help consumers to incorporate charging with other daily activities and spare time, however, this implies a change in the consumers' daily routine and attitude versus charging. This change seems to be difficult since similar to fuelling a conventional vehicle, charging an electric vehicle is considered as an activity on its own (Philipsen et al., 2015). Therefore, although BEV range amounts to approximately 200km (Ahmadian et al., 2020), the PHEVs capability of operating on both fuel and electricity increases the vehicle's range potential, overcoming range anxiety (Carley et al., 2019).

To increase the positive attitude towards BEVs, issues related to the location of charging points, charging time and charge density should be tackled (Halbey et al., 2015). The number of charging points needed to satisfy public demand varies from one country to another but range anxiety can contribute in increasing the demand for charging stations (Funke et al., 2019). Increasing the number of charging stations promotes a positive perception towards charging availability among consumers and a positive attitude towards BEV adoption (Carley et al., 2019), even among target groups that are not considered as being potential early adopters (Globisch et al., 2019). Charging stations need to be planned according to the consumers' driving patterns (Hardman et al., 2018) and also located at a reliable distance to reduce range anxiety (Davidov and Pantoš, 2017).

The strategy intended to expand the charging infrastructure should be part of the electric vehicle promotion policy (Hardman et al., 2018). To avoid excessive demand on the power grid, charging stations should not be free of charge. Charging the vehicle at a cost will avoid electric vehicle drivers from charging the vehicle unnecessarily, allowing the possibility for BEV drivers who need to charge their vehicle to utilise the infrastructure and provide turnover (Hardman et al., 2018). The establishment of price strategies can encourage individuals to charge the electric vehicle during off-peak hours in order to benefit from beneficial tariffs (Hamidi et al., 2009).

2.4.1. Grid-to-vehicle (G2V) and Vehicle-to-Grid (V2G) charging

Energy flow direction between an electric vehicle and the electric grid can be subdivided into two types (refer to Figure 2.2); grid-to-vehicle (G2V) and vehicle-to-grid (V2G). Grid-to-vehicle (G2V) refers to the process when an individual charges the electric vehicle utilising the electricity grid (García-Villalobos et al., 2014). On the other hand, vehicle-to-grid (V2G) involves the process of selling surplus power stored in the electric vehicle's battery by transferring it to the electric grid (Van Der Kam and van Sark, 2015; Madlener and Kirmas, 2017). Electric vehicles can be easily connected to the grid to transfer surplus power because many electric vehicles are most of the time parked (Mullan et al. 2012), even during hours of peak energy demand (Letendre and Kempton, 2002). The V2G concept is beneficial in controlling the charge load in an efficient manner (Li et al., 2020) and in addressing power instability associated with renewable sources of energy such as wind and solar power (Nebel et al., 2011; Pecas Lopes et al., 2009; Druitt and Früh, 2012). An individual owning an electric vehicle can charge the battery during the off-peak hours at an advantageous rate and sell the surplus power in the battery during peak hours at a higher price. Thus, V2G contributes in increasing both the utility of electric vehicles and in providing a smoother power distribution through the grid (Li et al., 2020). However, in order to have the V2G system fully operational electric vehicles should be equipped with high tension cables for safety purposes and a bidirectional charger to allow both battery charging and discharging. The effectiveness of the whole process depends on intelligent systems which transmit the necessary information between the electricity grid and the electric vehicle's battery, granting a controlled power flow between the two (Shariff et al., 2019). Furthermore, contracts between electric vehicle owners and electricity providers should be established for the smooth running of the operation (Nebel et al., 2011.

Although additional charging cycles associated with V2G deteriorate the battery at a faster rate (Geske and Schumann, 2018), integrating electric vehicles in the electric grid network is advantageous for all stakeholders (García-Villalobos et al. 2014) since following the initial purchase cost of the vehicle, batteries will store energy at no added cost (Mullan et al., 2012). Yet, to motivate the use of V2G, consumers should be motivated by designing a system that caters for the needs of different consumers. Frequent, long-distance drivers have different needs when compared to short-distance drivers, thus V2G use is not always motivated by economic incentives but also by tailor-made policies and information campaigns (Geske and Schumann, 2018).

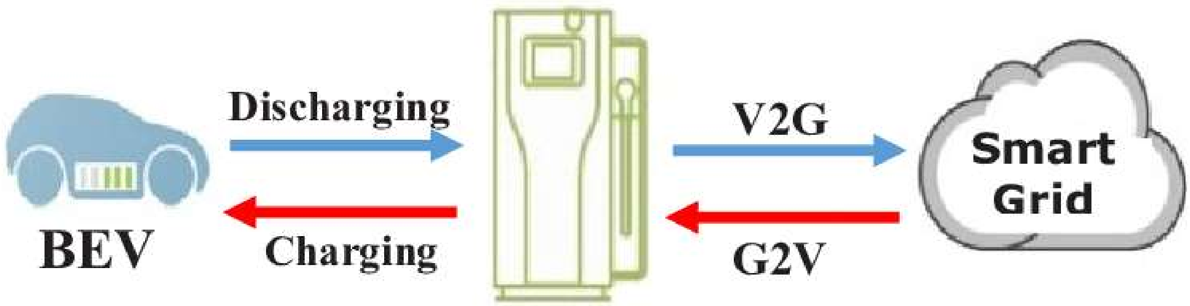

Figure 2.2: Energy flow in Grid-to-vehicle (G2V) and Vehicle-to-Grid (V2G) charging modes
Source: Rachid et al. (2019)

2.4.2. Battery swapping service

Battery swapping can serve as an alternative to the use of home chargers (Ungar and Fell, 2010) and/or public chargers (Yilmaz and Krein, 2013) to recharge a depleted electric vehicle battery. Battery swapping involves the substitution of a depleted battery with a fully charged battery in battery swapping stations. The swapping process overcomes barriers related to lengthy vehicle charging times and range anxiety (Sarker et al., 2015) since battery swapping takes only a short period of time (Xie et al., 2017), usually between 5 minutes to 15 minutes (Zhang and Rao, 2016; Rao et al., 2015). However, it is fundamental that battery swapping station operators account for the behaviour of electric vehicle users (Xie et al., 2017) by having in their possession a large quantity of batteries in advance in order to meet the consumers' demand (Rao et al., 2015). Not all electric vehicles run on the same type of battery; for example Nissan Leaf's built-in battery is composed of lithium and manganese while Tesla's battery is composed of nickel, cobalt and aluminium (Un-Noor et al., 2017). Therefore, an effective battery swapping process should provide batteries that are compatible with the different type of vehicles utilising the station (Zhang et al., 2020).

Battery swapping started to become more popular in China with the electrification of public transport. Due to the fact that taxis and buses perform extensive daily mileage they necessitate frequent charging. Thus, vehicles utilised in public transport are subject to long periods of inactivity if the vehicle takes a long time to charge. Battery swapping was identified as the solution to this problem (Rao et al., 2015; Kim et al., 2015, Gao and Wu, 2013). Battery swapping reduces the initial vehicle expenses since when buying an electric vehicle, consumers will pay for the vehicle without a battery which is then leased from a battery swapping station operator (Zhang and Rao, 2016). Therefore, electric vehicle users do not have concerns related to battery maintenance costs (Zhang and Rao, 2016; Rao et al., 2015; Zhang et al., 2020) which trigger an increase in the market of electric vehicles among price sensitive consumers (Zhang et al., 2020). Moreover, since batteries are maintained in an effective manner by the battery swapping station operator there is a higher tendency that the batteries' life is extended (Rao et al., 2015).

Similar to grid-to-vehicle (G2V) and vehicle-to-grid (V2G) charging, if the battery swapping station possesses a large quantity of batteries, the station's operator can exploit variations in the electricity market prices when charging batteries in order to benefit from advantageous rates (Borenstein, 2005; Rao et al., 2015). As illustrated in Figure 2.3, when the electricity price is low the discharged batteries can be charged using grid-to-battery (G2B) mode while when the market price is high, the battery swapping station can sell energy stored in the batteries to the grid (B2G) (Sarker et al., 2015). Supplying the grid with the energy stored in batteries can minimise the impact of electricity load fluctuations on the power grid caused by irregular charging patterns, thus improving the efficiency of the power systems (Salah et al., 2015; Cheng et al., 2013). Although a network upgrade in the location of the battery swapping station is necessary, an increase in the practice of battery swapping as an alternative to home charging among electric vehicle consumers, can help in reducing the need to perform any upgrades in the public electricity distribution network (Sarker et al., 2015).

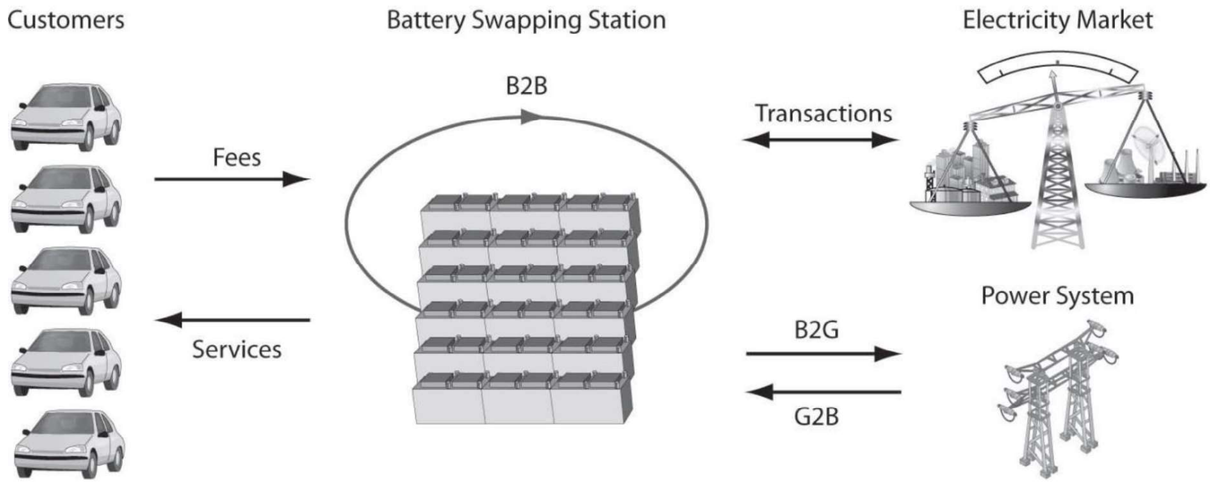

Figure 2.3: The battery swapping system
Source: Sarker et al. (2015)

Shao et al. (2017) state that during the current scenario, a consumer who wants to utilise a battery swapping station has to drive to the location of the station and wait for the individual's turn to swap the battery. Therefore, travelling to the swapping station and queuing in order to utilise the service can be time consuming, triggering range anxiety among consumers (Adler and Mirchandani, 2014). In order to overcome such constraints and benefits from battery swapping anytime and anywhere, Shao et al. (2017) propose the use of a mobile battery swapping station such as a battery swapping van. Electric vehicle users would be able to access the necessary information related to real-time location of battery swapping vans and the service price via a mobile application. On the other hand, the battery swapping van operator would be able to locate the electric vehicle user who requests the service utilising an in-built mapping software (Wang et al., 2015). Although battery swapping vans contribute to a flexible battery swapping service, the production of a reusable standard battery which is compatible with all electric vehicles can facilitate the provision of the service, encouraging consumers to buy more than one electric vehicle (Shao et al., 2017).

2.4.3. Extending the electric vehicle battery life cycle

An increase in the adoption of electric vehicles in the coming years will consequently contribute to the disposal of a considerable number of batteries that have reached their-end-of-life cycle (Wang et al., 2020). As illustrated in Figure 2.4, the first life cycle of an electric vehicle's battery initiates with the extraction of the raw material, proceeds with the manufacturing and the use of batteries. Finally, when the battery reaches the end of the life cycle, it is disposed (Reinhardt et al., 2019). Currently the four main types of batteries utilised in electric vehicle are lead-acid, nickel-metal hydride, lithium-ion (Li-ion) and nickel-nickel chloride (Andwari et al., 2017). Out of the four types, lithium-ion batteries are the most commonly used batteries (Wang et al., 2020; Reid and Julve, 2016) due to advantages associated with manufacturing and potentiality in extending their life cycle (Wang et al., 2020). It is important to note that batteries are composed from hazardous materials which contribute to environmental and health issues.

In order to avoid environmental pollution it is of utmost importance that a sustainable strategy is developed in order to recycle such batteries when they reach their end-of-life (Wang et al., 2020). Recycling materials from used batteries can reduce energy consumption, production costs and also help in preserving the lithium resource (Neubauer and Pesaran, 2011; Harper et al., 2019; Wang et al., 2020). Moreover, electric vehicle battery recycling and re-manufacturing contributes to 6.62% less greenhouse emissions when compared to battery manufacturing from raw materials (Xiong et al., 2020). Yet, the collection, transport and recovery of batteries can incur considerable expenses (Steckel et al., 2021). Thus, electric vehicle manufacturers can play an important role in facilitating the recycling of used batteries which can also generate a source of revenue to manufacturers (Jiao and Evans, 2016). Nissan and Volkswagen in the UK demand their customers to return their vehicle's used battery to an authorised centre for proper disposal (Volkswagen, 2022; Nissan, 2022). Volkswagen also collect for free waste batteries in order to be properly recycled (Volkswagen, 2022).

Electric vehicle batteries that reach the end of the first life cycle can be refurbished to extend the batteries' life (see Figure 2.4) by utilising them as a stationary energy storage connected to the electricity grid in households and businesses (Steckel et al., 2021). Similar to new batteries, second life batteries are also effective in storing energy but when compared to new batteries this can be done at a lower cost (Neubauer and Pesaran, 2011; Reid and Julve, 2016). Reusing batteries as a power storage and integrating them in the electricity grid can help in the development of a 'smart grid' where energy consumption can be managed according to the needs and prices (Heymans et al., 2014). Integrating lithium-ion batteries as a power storage in the power grid can also contribute to a 56% reduction in Carbon Dioxide emissions (Ahmadi et al., 2014). Furthermore, a household can become self-sufficient if second life batteries are coupled with photovoltaic systems where batteries get charged during the day and utilised during night-time to cater for the household energy demand. Therefore, the battery's second use can prove to be effective in delaying the process of recycling, by extending the battery's life by around 10 years (Reid and Julve, 2016). Giving a second use to batteries favours the concept of a circular economy (Reinhardt et al., 2019) which encourages the maximum use of a given resource in order to minimise waste generation (Klein et al., 2020). However, assessing the battery's health following the first life cycle is very complicated because the battery's health varies depending on charging rates as well as operational temperatures which differ among drivers according to the region where the electric vehicle was deployed. Thus, further studies regarding the battery's potential for a second use is necessary (Neubauer and Pesaran, 2011; Ahmadi et al., 2014).

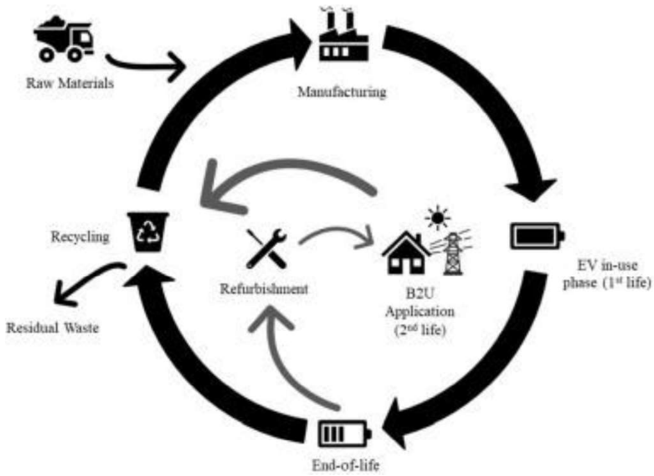

Figure 2.4: Electric vehicle battery first and second life cycles
Source: Reinhardt et al. (2019)

2.5. Battery safety in electric vehicles

Throughout the past years, a number of electric vehicle fire accidents were reported which as illustrated in Figure 2.5, occur while the vehicle is parked, during charging and also while driving (Jiang et al., 2021). Fire accidents are usually the result of misuse or abuse of the in-built battery, causing an internal short circuit and a thermal runaway (Xu et al., 2020). Li-ion battery technology which is widely used in the manufacturing of electric vehicle batteries, can serve as a fuel during electric vehicle fires similar to gasoline and diesel in internal combustion engine vehicles. However, controlling electric vehicle fires is more difficult because the battery pack is situated on the inside of the vehicle, thus not easily reachable by fire extinguishers. Fires generated due to battery failure can be followed by explosions and also by emissions of toxic gases (Wang et al., 2005; Sun et al., 2020). Since concerns regarding the safety of electric vehicles increased among the public, improvement in the vehicle's battery safety has become a priority (Xu et al., 2020).

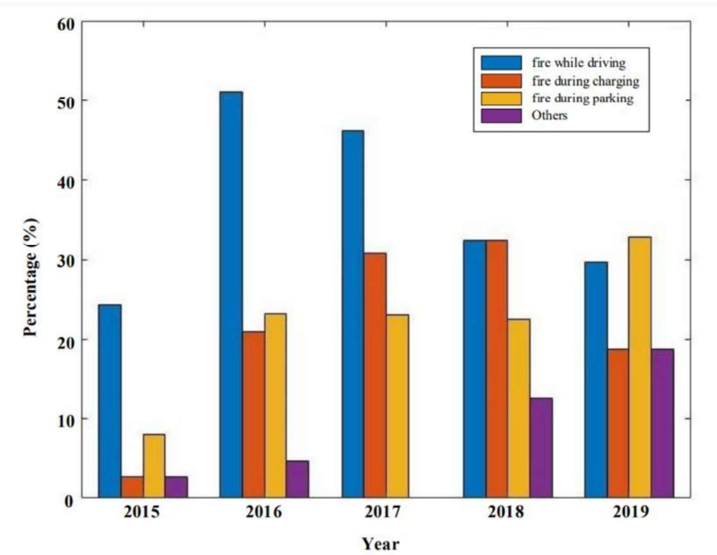

Figure 2.5: Worldwide electric vehicle fires from 2015 to 2019
Source: Jiang et al. (2021)

In order to minimise fire risks and improve the vehicles' safety, safety tests have been performed internationally following compulsory standards in order to evaluate the batteries performance in extreme environments or in abusive situations (Doughty and Crafts, 2006; Duan et al., 2019). Such tests are categorised into mechanical, environmental and electrical safety (Ruiz et al., 2018). Mechanical tests are intended to test the safety of batteries when subject to external mechanical forces such as vibration, rollover, drop, penetration, immersion, shocks and crushes (Xu et al., 2020). Environmental tests test the battery in extreme environmental circumstances which expose the battery to a range of temperature changes (Ruiz et al., 2018) while electrical safety tests are intended to minimise risks related short circuits and to battery overcharge and discharge. Although safety tests might indicate the existence of safety issues related to electric vehicle batteries, it is also important to consider the significant progress performed in detecting issues as early as possible, thus reducing possible risks (Xu et al., 2020).

2.6. Safety concerns related to low electric vehicle noise

Noise generated by vehicles is mainly the result of engine operation and tyre-road contact (Walker et al., 2016). Vehicle noise negatively impacts an individual's quality of life (Dratva et al., 2010; Brink, 2011) and can lead to mental health issues (Öhrström, 1991), sleep disturbances (de Kluizenaar et al., 2009) and cognitive impairment among children at school (van Kempen et al., 2012). The quietness of electric vehicle motors is one of the advantages of these vehicles (Cesbron et al., 2021) since it contributes to driving pleasure (Gärling, 2001) and increases comfort (Cocron and Krems, 2013). However, low noise associated with electric vehicles can pose a danger to pedestrians, cyclists (Everett et al., 2010) and blind people who depend on surrounding sounds to move safely in traffic (Emerson et al., 2011). When comparing the noise generated from both electric and ICE vehicles, major differences emerged when the vehicle speed is lower than 10km/hour (Garay-Vega et al., 2010; Morgan et al., 2011). Vehicle noise differences were lesser at 20km/hour (Morgan et al., 2011) and nil at a speed over 32km/hour (Garay-Vega et al., 2010). Therefore, accidents concerning pedestrians are more prone in locations where speed limits do not exceed 64km/hour and when the driver is involved in slow manoeuvres such as turning or exiting parking slots (Cocron and Krems, 2013). To counteract this problem the use of artificial sound at low speeds was mentioned in a number of studies to increase road users' safety (Sandberg et al., 2010; Sandberg, 2012; Dudenhöffer and Hause, 2013; Cocron and Krems, 2013). Sandberg et al. (2010) argued that modern ICE vehicles perform quietly, thus the difference between the noise generated from an electric vehicle and an ICE vehicle is minimal. Therefore, any measure to counteract the low sound of electric vehicles should also be applied to modern ICE vehicles (Morgan et al., 2011). It is expected that noise-related risks decrease with experience. Over time individuals become more cautious and drivers who become more aware about the hazards related to low noise

(Cocron et al., 2011), develop anticipatory skills to avoid noise-related accidents. Experience contributes to the development of a positive perception towards the electric vehicle's low noise, which starts to be considered as an increase in comfort (Cocron and Krems, 2013), motivating the acceptance of electric vehicles among consumers (Quak et al., 2016).

2.7. Marketing electric vehicles

Potential customers buying electric vehicles consider electric vehicles as a new propulsion system which removes many non-market disadvantages related to ICE vehicles such as greenhouse gas emissions. However, their high price, limited driving range, loading limitations due to the built-in batteries and lack of charging infrastructure are all disadvantages that influence the marketing of such vehicles (Garling and Thogersen, 2001). To compensate for such disadvantages skillful marketing is essential for electric vehicles to be accepted and get diffused in society (Weber and Hoogma, 1998; Kemp et al., 1998).

Although the development of effective national and international policies that favour the market acceptance of electric vehicles is an important measure, the effort will not be successful if a skilled and effective marketing effort is not performed by electric vehicle manufacturers (Tigert and Farivar, 1981). For a marketing plan to be effective, knowledge and understanding of both the early adopters and the product are necessary (Plötz et al., 2014; Hawkins and Mothersbaugh, 2010). Knowledge of consumer behaviour is crucial because the successful application of a marketing strategy requires human judgement which is dynamic. Furthermore, target customers must be provided with a more valuable alternative than the value provided to them by the competing product. Customer value can be defined as *the "difference between all the benefits derived from a total product and all the costs of acquiring those benefits"* (Hawkins and David, 2010, page 11). For example, the benefits related to the ownership of a vehicle depend on the person and type of car owned by the individual. In order to secure all the benefits, one has to purchase the vehicle, account for operation costs which include fuel, insurance, registration and maintenance. Furthermore, one has also to account for parking fees, risk of injury, environmental pollution and frustrations associated with traffic jams and limited parking space.

2.7.1. The influence of knowledge in electric vehicles adoption

Knowledge has an important role when consumers decide about the purchase of a particular product (Kaplan, 1991). Moreover, knowledge also influences the consumers' attitudes and intentions when deciding about the purchase of an environmentally friendly product (Burgess et al., 2013; Qian and Yin, 2017; Wang et al., 2017; Liu et al., 2018). Berliner et al. (2019) state that the main barrier which hinders electric vehicle adoption is the limited knowledge about the technology. Limited knowledge can result in the development of misconceptions and a negative attitude among consumers towards electric vehicles (Lane and Potter, 2007). In a study performed by Burgess et al. (2013), participants who lacked knowledge on electric vehicles developed a negative perception of such vehicles based on the performance and aesthetics of older electric vehicles.

Knowledge on the benefits and performance attributes of electric vehicles is crucial in promoting such vehicles (Lane and Potter, 2007; Burgess et al., 2013; Degirmenci and Breitner, 2017) since lack of knowledge decreases enthusiasm among potential electric vehicle adopters (Zhang and Yang, 2016; Wang et al., 2018; Xu et al., 2019). Thus, knowledgeable consumers will perceive less risks related to the novel product and will perceive the value and usefulness of the product differently when compared to consumers that are not well informed (Wang et al., 2018; Sung, 2010; Liu et al., 2018).

2.7.2. Effective marketing

Kotler et al. (2012) state that a successful marketing strategy should include the introduction of rebates or learning curve pricing so that the introduction price of a product is kept fairly low. Achieving market acceptance by few selected segments of the population should be the first focus of any strategy (Hawkins and Mothersbaugh, 2010).

Trialability is important in decision making, in fact customers demand a test drive before buying a new electric vehicle (Garling and Thogersen, 2001). Trialability helps in reducing concerns among consumers related to driving range and battery capacity limitations that might arise over time (Bandhold et al., 2009). Therefore, to motivate customers a generous return policy and an option to lease the electric vehicle for a period of time before the final decision is taken can increase the sales of electric vehicles. Extended test drives can be offered only after performing cost-benefit analysis; however, a short-term experience of electric vehicles can positively influence the attitude of consumers towards electric vehicles (Schmalfuß et al., 2017; Roberson and Helveston, 2020).

General Motors leased the EV1, an electric vehicle manufactured by the company between 1996 and 1999 for a three-year period without any purchase commitment. Furthermore, the company was also responsible for battery replacement if it developed a default (Murphy, 1997; Dipert, 1999). Daily experience of an electric vehicle results to be effective in changing preferences and attitudes towards electric vehicle adoption (Jensen et al., 2013; Turrentine et al., 2011). In a study performed by Carroll and Walsh (2010), a test drive contributed to an increase in the percentage of consumers who became willing to use an electric vehicle regularly while in another study by Turrentine et al. (2011), 71% of the participants became interested in purchasing electric vehicles following a lease period. However, the study performed in the UK by Graham-Rowe et al. (2012) shows that experience does not always guarantee positive attitudes towards electric vehicle adoption. Following a seven-day period of driving an electric vehicle most of the forty participants expressed concerns related to the driving range and battery capacity, thus were not willing to purchase an electric vehicle until further advancements in their technology was performed.

Electric vehicles are more appealing to that segment of society that is keen on environmental matters because these individuals will value the environmental friendliness of electric vehicles (Truffer et al., 2000). Although single car households might value the importance of environmental friendliness, an electric vehicle is likely considered as a risky investment. On the other hand, multi-car households are more open to electric vehicles since range anxiety concerns related to long trips can be solved by using an internal combustion engine vehicle at their disposition (Garling and Thogersen, 2001; Jensen et al., 2013).

Yet, the multi-car segment can be characterised by enthusiastic car owners who do not prioritise the environment, but attributes related to specific vehicles. Thus, car enthusiasts still might not opt for an electric vehicle as their second vehicle. Another variable related to multi-car household is that a number of these households, though being concerned regarding environmental issues, own multiple cars out of need due to different lifestyles and necessities among household members. Multi-car households may not consider the purchase of electric vehicles if they are more expensive when compared to conventional ICE vehicles. It is important that electric vehicles are marketed as an alternative to an ICE vehicle and not as a 'second car'. Promoting electric vehicles as a 'second car' will contribute to a rise in the number of vehicles on the road, especially if single car households become two car households, increasing traffic congestion and related problems (Garling and Thogersen, 2001).

2.7.3. Disruptive innovations in markets

Disruptive innovation refers to the process by which an innovative product or a service with limited resources challenges an established product or service referred to as incumbent, thus disrupting competition. Disrupters focus on the development of an effective business model and not just on the product, thus they identify and target gaps in market which are not attractive to incumbent companies or services (Danneels, 2004; Christensen et al., 2013). Incumbent companies try to satisfy the most demanding consumers by continuously developing their innovative product so that the company renders maximum profit. However, as illustrated in Figure 2.6 when the innovation becomes too sophisticated and expensive, it will not remain any more accessible for the low-end consumers. This situation creates space for disruptive innovations which target low-end consumers in order to fill the market gap. Disruptive innovations can challenge incumbent products if the disruptive innovation is subject to improvement which permits the innovation to move upmarket attracting also higher-end customers who are usually attracted by incumbent companies (Christensen et al., 2013).

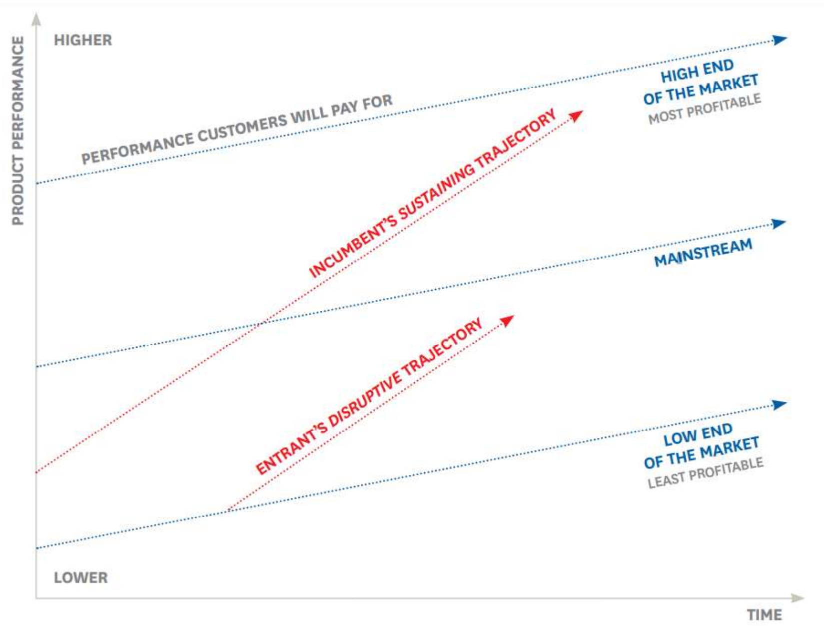

Figure 2.6: The disruptive innovation model
Source: Christensen et al. (2013)

Hardman et al. (2013) on the other hand state that initially, disruptive products are more expensive and less sophisticated when compared to incumbent products, yet disruptive innovations when compared to incumbent products can benefit from added attributes. Therefore, due to the initial high cost, disruptive innovations can target high-end customers in the top part of the market (Schmidt, 2004; van der Rhee et al., 2012). Over time and after the innovation lowers the costs, the innovation will spread downwards in the market to cater for the mass population (Hardman et al., 2015).

Technology does not necessitate to be brand-new in order to be classified as an innovation (Rogers, 2003). Thus, since battery electric vehicles are not a brand-new technology, they can be considered as being an innovation that is trying to emerge in the vehicle market. Battery electric vehicles are disruptive innovations (Pilkington and Dyerson, 2004) which have a higher cost when compared to incumbent conventional internal combustion engine vehicles. This explains why electric vehicle manufacturers who tried to produce vehicles in order to compete with internal combustion engine vehicles failed in their intent. On the other hand, Tesla Motors' marketing strategy proved to be successful because the company identified a market gap in the top part of the electric vehicle market, and decided to diffuse the first electric vehicle model, Tesla Roadster to high-end customers. However, this does not mean that targeting high-end consumers is the only suitable marketing strategy (Hardman et al., 2015) because targeting low-end consumers is also possible (Christensen, 2013). Low-end consumers can be reached by adopting a bottom-up marketing approach in which automakers utilise social media to engage directly with consumers and learn about the consumers' basic demands. Furthermore, since electric vehicles can be considered as a new product, the dissemination of learning and successes is fundamental to increase the deployment and avoid potential future issues (Springer, 2013).

2.7.4. The importance of aesthetics when marketing a product

The aesthetics of a product can influence the behaviour of consumers (Creusen and Schoormans, 2005; Homburg et al., 2015) and serves as a competitive advantage when promoting an innovative product (Liu et al., 2017). The appearance of a product provides an immediate and direct form of experience to the consumer which results to be more effective when compared to objective information to convince consumers to purchase the product (Bloch, 1995; Chitturi et al., 2008; Radford and Bloch, 2011). Although the aesthetic of a product is very important in the pre-adoption phase of the product, the importance of appearance can diminish in the post-adoption phase due to usage experience (Nagel and Schumann, 2020).

When judgements are performed on the appearance of a product without considering information on the product's performance, consumers tend to overestimate the usefulness of the innovative product (Hoegg and Alba, 2011). If the high expectations generated from the product design in the pre-adoption phase do not match with the product's utility during the adoption phase the product will not remain attractive to consumers (Churchill Jr and Surprenant, 1982). Therefore, apart from being aesthetically attractive, a novel product should also be useful, convenient and relatively easy to operate (Rogers, 2010; Venkatesh et al., 2012).

Innovative consumers value the aesthetics of a product more than other consumers (Truong et al., 2014). With the increase in the purchase of novel products, the product's aesthetics gains greater influence among innovative consumers when performing purchase decisions. Therefore, targeting innovative consumers will increase early adopters' satisfaction towards innovative aesthetics, thus facilitate effective marketing and diffusion of innovative products (Nagel and Schumann, 2020).

2.7.5. Branding in marketing

A brand is a name, or a trademark utilised by the manufacturer or the seller of a product as a means of identification on the market (Kotler, 2016). The consumers' purchase intention is highly influenced by the consumers' perception and feelings regarding a brand, also referred to as the brand image (Hsieh et al., 2004). The perceived value of a brand (brand equity) influences the consumers' attitudes when choosing among different brands on the market. A product manufactured by a brand that enjoys a positive brand equity attracts more consumers when compared to the same version of the product manufactured and sold by a generic brand (Kotler, 2016).

Brand awareness, which refers to the association of a brand to a specific category of products (Aaker, 1992) is considered as being the first stage in building a brand's value (Gartner and Ruzzier, 2011) and in developing an affiliation between value and the marketed brand among consumers (Keller, 1993). Jiang et al. (2021) state that low brand awareness and an inexact brand image can temporarily stop potential consumers from purchasing electric vehicles from new brands. When choosing from a range of brands that manufacture the same version of the product, consumers tend to opt for the most popular brands (Yasin et al., 2007) in order to reduce perceived risks related to the specific product (Manikandan, 2020).

2.8. Social influence on purchase motivation

Social influence is considered as an important determinant which affects the purchase motivation of electric vehicles since social influence has an impact on one's action or behaviour (Sridhar and Srinivasan, 2012; Cui et al., 2021). Potential adopters who are uncertain of an innovation, interact and consult with other individuals in the community (Burkhardt and Brass, 1990; Lu et al., 2005) thus, decisions are not taken in isolation but are influenced by the opinion of other individuals (Cialdini and Trost, 1998). In fact, according to Bart et al. (2015)

individuals' decision on whether to purchase or not an electric vehicle is not only influenced by the vehicle's price, costs or attributes but also influenced by the information obtained from other individuals. Due to social pressure, individuals compare their reasoning and action with those of other individuals to follow social norms based on perceived expectations (Thøgersen, 2006). Therefore, social interaction contributes to the development or modification of personal norms which similar to social norms can guide an individual's behaviour (Jansson et al., 2017) to act in favour of the environment (Goldsmith and Goldsmith, 2011).

In a social context, opinion leaders are innovators that are capable of communicating their opinion effectively, influencing the attitudes and actions of other people who are opinion seekers (Venkatraman, 1989; Rogers, 2003; Weimann et al., 2007). Therefore, the diffusion of an innovation can be facilitated by opinion leaders since they tend to be socially active and demonstrate high mass media readership (Rogers, 2003). However, if the opinion leader perceives an undesirable innovation which is not favoured by the social norm, the opinion leader tends to slow down or prevent the diffusion (Rogers, 2003).

Customers tend also to associate themselves with reference group/s, which are groups who cherish particular perspectives and values that are utilised by people as a guidance for their behaviour in a specific situation (Hawkins and Mothersbaugh, 2010). When an individual identifies himself/herself with a specific group, the individual's attitudes and behaviour change according to the perceived norms of the group (Barth et al., 2016). If the group is prominent in society, the individual is further motivated to follow the group's practices (White et al., 2009; Terry et al., 1999; Masson and Fritsche, 2014). Therefore, electric vehicles adoption is highly influenced by the social norms of the reference group/s in society. An individual will be motivated to purchase an electric vehicle if he/she perceives that the members of the reference group/s are in favour of electric vehicle adoption (Barth et al., 2016).

The products purchased by consumers reflect the consumers' identity (Aaker, 2012), therefore consumers develop a stereotypic image of the clients of a specific product of a specific brand, known as product user image (Sirgy et al., 1992) or brand-user image (Kressmann et al., 2006). When consumers compare the perceived actual self-image with the image he/she has of the buyers of a specific product (self-image congruence), the consumer is motivated to purchase the product only if the brand-user image corresponds to the perceived self-image (Jamal and Goode, 2001; Kressmann et al., 2006).

As illustrated in Figure 2.7, Rogers (2003) subdivides the social process that contributes to the acceptance or rejection of an innovation such as electric vehicles into five stages; knowledge, persuasion, decision, implementation, and confirmation. Initially, individuals who are exposed to the innovation seek information about the innovation (knowledge stage) which determines whether the individual develops a positive or a negative attitude towards the innovation (persuasion stage). After considering the advantages and disadvantages of the innovation the individuals decide whether to adopt or reject the innovation. Due to an element of uncertainty, the implementation stage helps the individual to determine the usefulness of the innovation. In the confirmation stage the attitude of the individual determines whether to proceed or otherwise with the innovation. The consumer's choice can be determined by the social judgement criteria of the innovation and the consumer's willingness to follow the norms established by peers (Hu et al., 2019; Sridhar and Srinivasan, 2012).

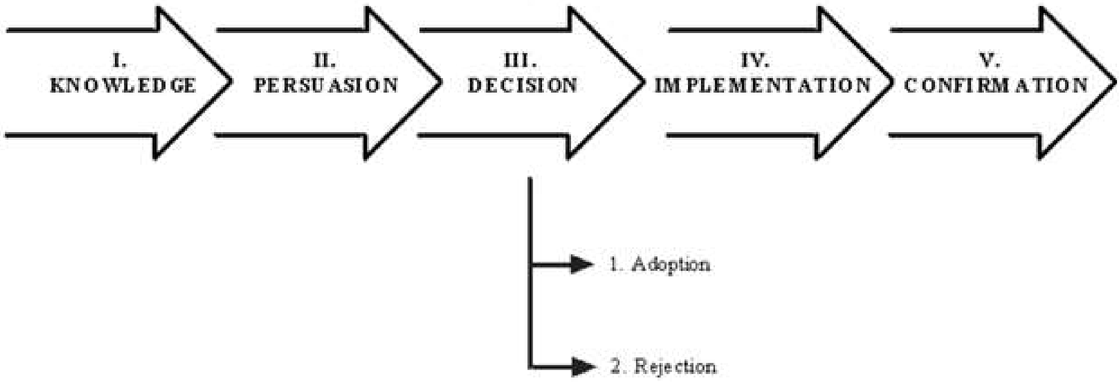

Figure 2.7: The social process leading to the diffusion of an innovation
Source: adapted from Rogers (2003)

Green consumerism refers to attitudes that promote the purchase and consumption of environmentally friendly products (Matthes and Wonneberger, 2014). Social influence is positively correlated with green consumerism (Clark et al., 2019) and electric vehicle adoption (Larson et al., 2015). Although a number of consumers are in favour of green consumerism, they do not always act accordingly when purchasing a product due to other attributes that influence their choice (Magnusson et al., 2001; Schuitema and De Groot, 2015). In order to instil green consumerism in society, such behaviour should be considered by consumers as a norm (Rettie et al., 2012). When green consumerism becomes a social norm, consumers will be subject to social pressure to adopt an environmentally friendly behaviour to conform with the norm (Gabler et al., 2013; Clark et al., 2019). Social pressure in favour of environmentally friendly products benefits businesses that sell green products since consumers will adopt a positive attitude towards the marketed product (Olsen et al., 2014).

2.9. Financial attribute as a limiting factor

Price is a factor that is considered by consumers during decision making and influences consumers' motivation when purchasing goods or services (Liang et al., 2017; Cui et al., 2021). The major barrier associated with electric vehicles is related to the high purchase price (Sierzchula et al., 2014; Larson et al., 2015; Junquera et al., 2016) which is conditioned by the high battery and motor control system costs. The aforementioned costs-render the production cost of BEVs higher than conventional vehicles (Adepetu and Keshav, 2015; Barisa et al., 2016). Consumers are sensitive to both price and driving range, which are both related and impact each other (Lieven et al., 2011). An increase in battery capacity contributes to a higher driving range, yet, this has an impact on the battery price which currently is already very expensive (Adepetu and Keshav, 2015).

According to Lingyun et al. (2011) consumers tend to purchase electric vehicles when their price is relatively low. In accordance with Lingyun et al. (2011), the study performed in Latvia by Barisa et al. (2016) acknowledges that attitudes by potential users would improve if the vehicle price was reduced by 41% - 50% since most of them will not see the price as an economic barrier. Moreover, if the price was reduced by 71% - 80% the price barrier will lose its significance. The conclusions made by Barisa et al. (2016) contrast with Jabeen et al. (2012) and Skippon and Garwood (2011) who state that experienced drivers have a higher purchasing power when compared to inexperienced drivers and are more willing to pay a high price for an electric vehicle. However, She et al. (2017) pointed out that experience will not always trigger the purchase of an electric vehicle.

Reduced prices do not necessarily contribute to a higher demand for the product. If consumers associate low prices with low quality products, the demand for the product might decrease (Palma et al., 2016). A consumer is usually influenced by an internal reference price, which is the price expected by the consumer based on adverts and promotion. The internal reference price is utilised as a guideline with which product prices are compared (Maxwell, 2002). The consumers' decision is not conditioned if the product's price varies slightly when compared to the internal reference price but if the price exceeds considerably the internal reference price the consumer will be unwilling to purchase the product (Han et al., 2001). Price sensitivity among consumers varies according to the functionality of the product, thus, consumers are less eager to purchase a product or a service if it does not cater for their needs (Cui et al., 2021). Furthermore, price sensitivity is also determined by the consumers' income. Consumers with a high income are less sensitive to changes in prices, especially when it comes to the purchase of hedonic products. On the other hand, consumers with a low income are very sensitive to price changes regardless of whether the product is hedonic or functional (Wakefield and Inman, 2003).

Another economic aspect that impacts the adoption of electric vehicles is the relative price of electricity (Hidrue et al., 2011). Electricity is crucial in the smooth operation of both plug-in hybrid and battery electric vehicles (Fazli Khalaf and Wang, 2018). Therefore, since the daily operation cost depends on the price of electricity, consumers can be discouraged to purchase electric vehicles if electricity prices are high (Adhikari et al., 2020). The provision of a dynamic pricing system such as the time-of-use (TOU) tariffs can result to be more attractive to electric vehicle adopters when compared to flat rates. When flat rates are adopted, consumers pay according to the total kilowatt hours (kWh) of electricity consumption. On the other hand, time-of-use (TOU) tariffs provide more flexible pricing, where usually prices are highest during peak hours and lower during off-peak hours. Thus, time-of-use (TOU) tariffs allow both plug-in hybrid and battery electric vehicle owners to benefit from lower tariffs keeping the electricity bill sustainable (Fazli Khalaf and Wang, 2018).

In a study performed in 2016, Skippon et al. mention that the performance of an electric vehicle plays a more influential role when compared to economic benefits in the acceptance of such vehicles. Ozaki and Sevastyanova (2011) also obtained similar conclusions to Skippon et al. (2016) since according to their study, factors such as high-quality performance and low noise are variables that would influence the consumers' decision. Yet, vehicle cost and the vehicle's performance are considered more important factors especially when compared to environmentalism (Lane and Potter, 2007; Egbue and Long, 2012).

Several studies on the total cost of ownership of electric vehicles indicate that such vehicles are subject to a larger loss in their purchase value when compared to internal combustion engine vehicles due to continuous improvements in technology (Lévay et al., 2017; Palmer et al., 2018). One has also to take into account that as vehicle technology matures, manufacturing costs decrease by time, which in turn will influence the total cost of ownership. (Palmer et al., 2018). However, since the market of used electric vehicles is still small, it is very difficult for the consumer to predict the future value of the vehicle (Zhang and Zhao, 2021).

Depreciation due to developments in technology and the restricted market for used battery electric vehicles generates 'resale value anxiety' among consumers (Guo and Zhou, 2019; Dua et al., 2019; Lim et al., 2015). To minimise consumer 'resale anxiety' vehicle manufacturers give guarantees related to the battery's capacity and guarantee a resale value similar to internal combustion engine vehicles (Lim et al., 2015; Zhang and Zhao 2021). Although certain studies assume that electric vehicle resale price is comparable to that of internal combustion engine vehicles (König et al., 2021; Carley et al., 2019; Sharma et al., 2012), others state that it is not feasible to establish electric vehicle resale prices (Letmathe and Suares, 2020) due to limited historical data (Hagman et al., 2016). Therefore, there is the tendency for consumers who are anxious regarding the depreciation of electric vehicles to prefer leasing instead of purchasing such vehicles (Dua et al., 2019).

In choice experiments, fuel costs condition the utility of vehicles (Higgins et al., 2017; Axsen et al., 2015, Jensen et al., 2013). On the other hand, a study based in Virginia resulted in maintenance costs having a less significant role in the choice of vehicle (Jia and Chen, 2021). The latter study contrasts with the study performed in Canada by Ferguson et al. (2018) which reported that annual vehicle maintenance costs influenced utility in a negative manner. This trend was especially evident amongst BEV-oriented respondents. Fuel and maintenance costs were combined as an operational cost attribute by Mabit and Fosgerau (2011) and it was concluded that operational cost attributes conditioned negatively vehicle purchase decisions.

2.9.1. Incentive policies

The incentive policy is one of the most common instruments applied by governments to encourage large-scale adoption of electric vehicles. Incentives aim at increasing the competitiveness of electric vehicles in the current market (Zhang et al., 2018).

Bjerkan et al. (2016) categorised various economic and non-economic measures and incentives adopted in Europe (Kley et al., 2012), USA (Jin et al., 2014) and worldwide (Leurent and Windisch, 2011) which intend to overcome the barriers that hinder the adoption of electric vehicles. The measures and incentives are explained in Table 2.1. Although the categorizations of incentives differ, in the literature there is a general agreement on the relevant and appropriate incentives. Most of the measures are 'pull measures' because their aim is to encourage the purchase of electric vehicles rather than discouraging the purchase and use of internal combustion engine vehicles. However, incentives favouring the purchase of electric vehicles will also indirectly act as disincentives for the purchase of internal combustion engine vehicles (Bjerkan et al., 2016).

Kley et al. (2012)	**Economic:** Influencing the market outcome by performing changes in the prices. Changes can include tax reduction and subsidies, the introduction of CO_2 certificates, congestion charges, parking fees and old vehicle scrapping scheme.	**Regulatory:** Introduce restrictions on the inputs, outputs and production processes of vehicle manufacturers such as the imposition of emission targets.	**Persuasive:** Persuade both buyers and manufacturers by funding research and development programs and providing the necessary information utilising special labelling and/or carrying out information campaigns.	**Organisational:** Invest in the necessary structures such as charging infrastructure and free parking spots.	
Jin et al. (2014)	**Direct incentives**: These incentives include purchase subsidies, reduction in license tax/fees, rebates related to home chargers and public chargers, free electricity, free parking.	**Indirect incentives**: Such incentives are not intended to give a monetary value but to save time and provide convenience to people such as the access to carpool lane for electric vehicles and the availability of public chargers.			
Leurent and Windisch (2011)	**Economic**: It intends to overcome cost barriers related to electric vehicles by giving financial incentives to potential buyers which include purchase subsidies, tax incentives and the construction of electric vehicle infrastructure.	**Command and control:** Authorities apply measures on a national scale to promote electric vehicles. Such measures include directives for manufacturers to adopt cleaner technologies and encourage consumers by exempting electric vehicle users from specific restrictions such as parking and driving restrictions.	**Collaborative**: The government should coordinate researchers, manufacturers, authorities, and customers so that voluntary agreements between all stakeholders favour new mobility practices.	**Communication and diffusion**: The dissemination of information and education are important to enhance the public's interest in electric vehicles.	**Procurement:** Enhance the demand for clean vehicles by increasing their number, thus enabling scale economies. The government or a consortium of stakeholders invests in a number of clean vehicles, in order to benefit from cheaper prices.

Table 2.1: Categorization of measures and incentives intended to promote electric vehicle adoption.
Source: adapted from Bjerkan et al. (2016)

2.9.2. Fiscal incentives

In the White Paper published by Mock and Yang (2014), incentives utilised to increase the sale of electric vehicles were categorised into direct subsidies, fiscal incentives and fuel cost savings. Direct subsidies involve a one-time bonus obtained on purchasing an electric vehicle. Fiscal incentives are often offered in the form of reduced purchase price and/or exemptions from purchase tax. Up-front reduction in the purchase price resulted to be an effective measure in a study performed in Norway by Bjerkan et al. (2016). Eighty per cent of the respondents showed that exemptions from VAT and purchase tax are significant incentives especially if the price of electric vehicles is roughly equal to the price of a corresponding ICE vehicle.

In addition to up-front reduction in the purchase price, certain incentives make vehicles cost-efficient and convenient for daily use (Bjerkan et al., 2016). Fuel cost savings are influenced by lower electricity prices and the higher efficiency of electric vehicles when compared to fuel cost and level of efficiency of internal combustion engine vehicles (Mock and Yang, 2014). Bjerkan et al. (2016) also suggest that road tolling exemptions, free parking and ferry tickets and access to bus lanes can contribute positively to incentivise the purchase of electric vehicles. Such incentives proved to be significant for half of the sample studied.

Studies performed by Mock and Yang (2014) and Figenbaum et al. (2015) indicate that fiscal incentives matter when consumers are intended to buy an electric vehicle. When the first PHEVs were launched in Norway in 2012, lack of incentives to counteract the vehicles' high price limited the sales of such vehicles. However, incentives alone do not necessary correspond to an increase in the sale of electric vehicles. This fact was also outlined by Mock and Yang (2014) when stating that despite the high fiscal incentives in UK, the number of electric vehicles remained low when compared to other countries such as the Netherlands and Norway.

According to Sierzchula et al. (2012) it is very difficult to estimate the impact of financial incentives on electric vehicles. Such vehicles present a radical technological change when compared to internal combustion engine vehicles and HEVs (Sierzchula et al., 2012), generating a lot of uncertainty among consumers (Sovacool and Hirsh, 2009). Consumers are less willing to pay for an innovation which differs considerably from conventional technology. (Sierzchula et al., 2012). If consumers are not comfortable with the technology or do not observe a number of electric vehicles around them, subsidies may have minimal effect on the sales of electric vehicles (Egbue and Long, 2012; Eppstein et al., 2011).

As illustrated in Figure 2.8, when buying an electric vehicle, consumers should consider both the purchase price and ownership costs and not focus only on the purchase price (Turrentine and Kurani, 2007). The total cost of ownership is a financial estimate that incorporates the purchase price and the sum of all costs related to the ownership of a product. Therefore, it helps the consumer to understand the total expenses associated with an asset and evaluate better its affordability when performing purchase decisions (Ellram, 1995). Individuals who are aware of partial information, instead of performing rational decisions, often calculate the total cost of ownership on heuristics when purchasing a product (Schleich, 2009). Liu et al. (2020) state that although government subsidies and tax reduction can serve as an incentive to buy BEV, inexperienced electric vehicle drivers may lack knowledge of the low price of charging when compared to the price of fuel. This may result in irrational behaviour since consumers opting for electric vehicles may not include fuel economy in their vehicle purchase decisions (Turrentine and Kurani, 2007).

In a survey performed by Krause et al. (2013) in 21 USA cities, 75% of the respondents underestimated the value of plug-in electric vehicles due to wrong perceptions related to the total cost of ownership. Therefore, providing total cost of ownership calculations on a label showing operational cost savings of electric vehicles can increase sales (Dumortier et al., 2015). Informative labels can be effective since although car buyers consider fuel savings as an important attribute (Nixon and Saphores, 2011), consumers rarely perform calculations to compare the high purchase cost with the high fuel cost savings (Axsen and Kurani, 2012). If consumers have inflated perceptions of the total cost of ownership of electric vehicles, it is unlikely that consumers purchase such vehicles (Krause et al., 2013). Providing information on the total cost of operation of electric vehicles can serve as a low-cost tool to market electric vehicles (Dumortier et al., 2015).

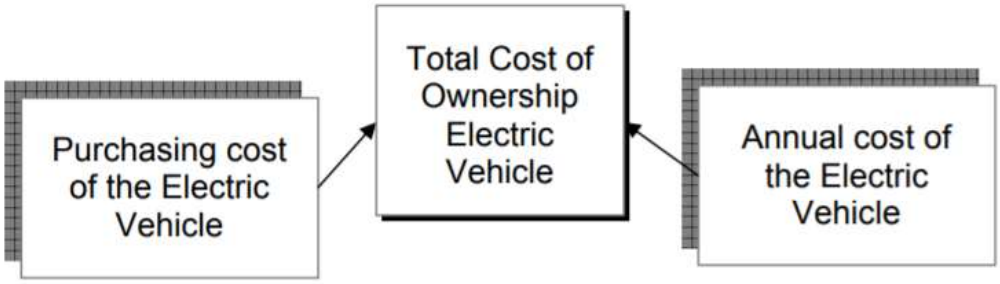

Figure 2.8: Total cost of ownership of an electric vehicle.
Source: adapted from García and Miguel (2012)

In a longitudinal study performed in 14 countries, Sprei and Bauner (2011) found that between 2009 and 2011 though the effect of incentives is statistically proved, the effect is relatively minimal. Thus, it was concluded that to increase sales high incentives are needed. The regression analysis performed by Sierzchula et al. (2014) on the sales of electric vehicles in 30 countries contrasts with Sprei and Bauner's (2011) findings, since it was found that financial incentives are important in increasing sales. However, Sierzchula et al. (2014) referred also to the presence of a local electric vehicle manufacturer as an equally important factor to increase sales. When comparing BEV and PHEV fiscal incentives in different countries, Mock and Yang (2014) concluded that although fiscal incentives are important, the relationship of such incentives with electric vehicle sales is unclear. According to Gallagher and Muehlegger (2011) purchase taxes are more effective on sales when compared to income tax credits. Despite this, Figenbaum at al. (2015) point out that electric vehicles' incentives are commonly criticised as being subsidies for the wealthiest people in society.

In more advanced stages of change, consumers' sensitivity to price decreases, thus subsidies become less effective when purchasing an electric vehicle. During advanced stages of change, consumers consider the gap between the utility of electric vehicles and that of internal combustion engine vehicles minimal. Thus, they opt for electric vehicles because they have a high intrinsic motivation (Langbroek et al., 2016).

To measure the effectiveness of a policy it is important to assess the side effects of the incentives (Langbroek et al., 2016). Givoni et al. (2013) propose the inclusion of electric vehicle policy in a 'policy package' which considers a broader context. The 'policy package' is intended to consider both the adoption of electric vehicles and the associated rebound effects. Incentives such as the reduction of parking prices, access to bus lanes and lower electricity costs decrease the marginal costs of electric vehicles. The reduction in marginal costs make electric vehicles more attractive since the mentioned advantages serve as a compensation to the higher purchasing price of electric vehicles. When reducing the marginal cost of electric vehicle trips, indirectly one is encouraging people to increase the use of their vehicle. Moreover, reducing the marginal costs will not help those individuals who are interested in purchasing an electric vehicle but cannot afford the purchase price (Langbroek et al., 2016).

Zhang and Bai (2017) state that if the purchase of electric vehicles is only motivated by subsidies, when subsidies are phased out, the sales of electric vehicles will not last for long due to financial concerns. Therefore, although policy incentives are not intended to be provided forever, policy incentives remain in place until the electric vehicle market gains popularity, becoming self-sustaining (Langbroek et al. 2016).

2.10. Openness to experience

Openness to experience was identified as being fundamental in enhancing responsible social behaviours (Luchs and Mooradian, 2011). The purchase motivation of individuals who intend to buy an electric vehicle is influenced by their "openness to experience". The extent of creativity, curiosity and preference for innovations and variety are influential factors that affect electric vehicles' purchase motivation (Cui et al., 2021). An individual's personality which differs between persons, affects one's choices or reaction to various situations (Gustavsen and Hegnes, 2020). Individuals who are highly open to a novel experience would be more motivated to buy an electric vehicle (Cui et al., 2021). Consumers are also influenced by their self-esteem needs (Truong and McColl, 2011). People with a high self-esteem are more willing to gain acknowledgment from others (Hanley and Wilhelm, 1992). Thus, it is more likely that an individual with high self-esteem is open to purchase an electric vehicle. The fact that such vehicles are considered environmentally friendly vehicles serves as an incentive for the individual, knowing that s/he will gain acknowledgement and respect from other individuals in society (Cui et al., 2021).

Collective efficacy; that is the belief in the group's ability in affecting important aspects of the environment and promoting pro-environmental action can play a fundamental role in promoting collective change. Although global issues cannot be solved easily, acting as a group increases the power to make a difference. Thus, using an electric vehicle can be considered as a personal contribution in order to reach a collective goal (Jugert et al., 2016).

2.11. Research outcomes on electric vehicle adoption in the Maltese Islands

Electric vehicles in Malta can still be considered as a relatively new vehicle technology since adoption of such vehicles is still in its initial phases (Cuschieri, 2020). This is evident in the study performed by Ahomaa (2018), where over 85% of the respondents did not experience an electric vehicle. In the same study only 52.5% of the respondents showed interest in purchasing an electric vehicle, the majority of which were males who had already driven such a vehicle. After just two years Camilleri (2020) found contrasting results with 103 out of 500 participants, most of whom were car enthusiasts, were not willing to purchase an electric vehicle.

Maltese who are interested in innovative technology are significantly correlated to electric vehicle adoption (Farrugia, 2018) but perceive that ultimately automobile technology incurs a high price (Barbara, 2011). According to Cuschieri (2020) social norm has an influential role in decision making because if an individual's decision to adopt an electric vehicle is not supported by family members and friends, most probably the individual will not purchase such a vehicle. However, contrasting results were illustrated in the study performed by Barbara (2011) where the majority of the respondents were not influenced by external opinions from friends, neighbours, co-workers or opinion leaders.

Barbara (2011) also pointed out that the respondents' exposure to advertisement associated with electric vehicles was minimal, yet the majority of the respondents did not perceive electric vehicles negatively. Similar conclusions were outlined by Camilleri (2020) where 73.8% of the respondents stated that the marketing campaign of Malta-based car companies does not have an influential role in incentivising the purchase of electric vehicles. In order to minimise perceived risks caused by low electric vehicle exposure among Maltese, individuals tend to give importance to brand and reputation (Barbara, 2011; Pisani, 2020) during decision making, overlooking technical features (Pisani, 2020). Furthermore, consumers tend to visit several dealers, speak with their friends and read reviews or consult online sources to gain knowledge (Barbara, 2011). Yet, knowledge obtained can still be restricted since although the participants in Camilleri (2020) were familiar with Tesla as an electric vehicle manufacturer, they were much less familiar with Mercedes, Volkswagen and Renault as electric vehicle manufacturers. Therefore, informative campaigns on a national scale can be fruitful in minimising concerns and in the promotion of a positive social norm (Cuschieri, 2020).

Individuals belief that both electric and conventional vehicles have similar aesthetics, performance (Barbara, 2011) and are easy to drive (Farrugia, 2018). However, they have concerns related mainly to the vehicle price, charging convenience (Barbara, 2011; Ahomaa, 2018; Farrugia, 2018; Pisani, 2020; Camilleri, 2020), battery life and replacement cost (Ahomaa, 2018), the lack of second-hand vehicles (Farrugia, 2018), the limited availability and cost of mechanics (Cuschieri, 2020) as well as that of spare parts (Farrugia, 2018). Uncertainty among consumers is hindering the rate of electric vehicle adoption in Malta, in fact, although certain consumers might financially afford an electric vehicle, they tend not to purchase such a vehicle (Cuschieri, 2020). Other consumers might condition other individuals, especially when it comes to newly licensed 18-year-old consumers some of whom are still financially dependent on their guardians (Farrugia, 2018). On the other hand, those consumers who associate hybrid electric vehicles to conventional vehicles, tend to opt for the former vehicles instead of other electric vehicle options (Barbara, 2011).

The amount of money individuals are willing to spend to purchase an electric vehicle is influenced by both their intent and the sum the customer is willing to pay for the purchase of a conventional vehicle (Farrugia, 2018). Consumers agree that it is cheaper to run an electric vehicle when compared to a conventional vehicle (Farrugia, 2018; Pisani, 2020), yet, the perception that the price of electric vehicles is more expensive exists among the general public (Pisani, 2020). Awareness about the existence of government grants proves to be effective in promoting a positive intent towards electric vehicle adoption. In fact, University of Malta students who were aware about the grants were three times more likely to purchase an electric vehicle when compared to those students who were unaware of the grants (Pisani, 2020). However, awareness about the financial benefits associated with electric vehicle adopters resulted to be very low among the respondents participating in the study performed by Ahomaa (2018). Only 26.3% of the respondents were aware of the government grant scheme while 35%

of the respondents were aware that electric vehicle owners benefit from subsidies related to registration tax and road licence.

Financial grants tend to be effective if they lower the price of electric vehicles at the same level as that of conventional vehicles (Farrugia, 2018). If the price of an electric vehicle is on the same level as the price of a conventional vehicle more consumers will opt for an electric vehicle (Ahomaa, 2018; Cuschieri, 2020). In the study performed by Farrugia (2018) among Maltese of 18 years of age and older, the government grant which at the time of the study amounted to €7,000 was not influential on the customer's purchase intent or on the price a customer was willing to pay to purchase an electric vehicle. The €7,000 grant did not contribute to a positive attitude to electric vehicle adoption because conventional vehicles still remained cheaper, thus more attractive to consumers.

Both Farrugia (2018) and Pisani (2020) study if electric vehicle adoption is associated with environmental concern. Farrugia (2018) studies the relationship between people who recycle and electric vehicle adoption whilst Pisani (2020) studies the relationship between individuals who utilise multiple modes of transport and electric vehicle adoption. In the respective studies it is assumed that people who recycle and multimodal individuals are environmentally conscience individuals, thus keener to purchase an electric vehicle. However, in both instances no relationship was identified. Multimodal individuals resulted to be less willing to purchase an electric vehicle because they do not depend solely on their private vehicle (Pisani 2020). Furthermore, Farrugia (2018) concluded that the purchase of electric vehicles is not seen as a means to safeguard the environment but as an investment with a possibility of a return.

Electric vehicle adoption tends to be problematic for those individuals who do not own a garage and therefore unable to charge their electric vehicle. In order to overcome this issue a number of applications were issued so that a number of charging points are located in residential areas and commercial establishments (Transport Malta, 2013). Increasing the number of charging stations can help in increasing the intention to purchase an electric vehicle (Cuschieri, 2020) since according to Pisani (2020), consumers are not discouraged of having to plug-in and unplug the electric vehicle every time the need arises to recharge the vehicle's battery. Although a number of consumers are positive with regard to electric vehicle's battery range, a number of individuals still have their concerns on the matter (Cuschieri, 2020). Pisani (2020) stated that 55% of the respondents were afraid that the vehicle battery gets depleted before the opportunity to charge. Yet, only 42.5% of the participants participating in Farrugia (2018)'s study, were aware of the closest charging point to their home. Furthermore, when Pisani (2020) presented a scenario with an increased number of charging points, only 16% of the respondents changed their opinion regarding electric vehicle adoption. Therefore, it was concluded that consumers are influenced by other determinants and electric vehicle adoption might only be considered if the individual can benefit from home charging (Pisani, 2020).

2.12. Conclusion

In this chapter a brief overview regarding the design of hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) which are the three main types of electric vehicles on the market was given. Out of the three designs, only battery electric vehicles (BEVs) depend exclusively on the in-built battery to operate. Since plug-in hybrid vehicles (PHEVs) are capable to operate utilising both an internal combustion engine and an on-board battery, these are currently considered as being the least risky option by those individuals who due to lack of exposure and knowledge still have different concerns regarding such investment. However, perceptions regarding electric vehicles differ across different socio-demographic segments in society. Young and middle-aged people especially males who are more inclined towards technological innovations are more prone to adopt electric vehicles. In literature early adopters are also associated with people who have a high level of education and knowledge which in turn increases awareness about environmental issues, triggering a pro-environmental behaviour. Yet, large multi-car households often utilise electric vehicles for short trips due to range concerns, thus in such situation electric vehicles turn out not to be an alternative to internal combustion engine vehicles but just another addition. Therefore, one can conclude that electric vehicle adoption differs across different countries in the world due to different variables.

Literature indicates that drivers tend not to be eager to change their driving behaviour. Thus, increasing the number of charging points along different routes which are capable of charging electric vehicles in the shortest time possible can help in encouraging electric vehicle adoption, especially among those who do not own a garage. Furthermore, vehicle-to-grid charging options and the use of second-life batteries as an energy storage help in maintaining stability in the power grid as well as generate a source of profit to individuals who take advantage of time of use (TOU) favourable price rates.

This chapter also accounts for the importance of adopting an effective marketing strategy by both manufacturers and policy makers to incentivise potential electric vehicle adopters. The brand and the aesthetics of the product as well as economic and non-economic incentives resulted to be effective, yet not a guarantee of an increase in purchases. Moreover, individuals that lack electric vehicle knowledge and experience are influenced by the social norms cherished by reference group/s or opinion leaders in society during decision making. Thus, an individual's "openness to experience" can be fundamental in affecting purchase motivation.

The last part of the chapter gives an overview of the research outcomes on electric vehicle adoption in Malta. It is important to point out that previous research in the Maltese Islands was performed prior to the launch of the latest significant financial subsidy increase. Thus, no research accounts for the effectiveness of current grants in motivating electric vehicle adoption. Although previous research in the Maltese Islands identified that certain individuals were not aware of the existence of government grants and that Malta-based car companies are not having an influential role in decision making, no research studied the role of knowledge in increasing electric vehicle adoption. Therefore, the following chapter is intended to discuss the research methodology adopted to cater for these aforementioned research gaps.

CHAPTER 3: RESEARCH METHODOLOGY

3.1. Aim and objectives

The limited purchase of electric vehicles in Malta over the years is a major concern which the Maltese government has tried to solve by introducing and increasing financial incentives associated with the adoption of electric vehicles. The government is also trying to facilitate the change by investing in charging infrastructure and planning to strengthen the power supply so that the power grid will eventually cope with an increase in electricity demand. Yet, as outlined in the introductory chapter, although the Maltese government intends to introduce 1,200 new charging points by the year 2024, only 340 charging points are currently operational in the Maltese Islands. Furthermore, plans related to the installation of the second interconnector are still in the preliminary stages (Caruana, 2022).

The aim of the research is to evaluate if the price and running costs of electric vehicles are determinant barriers among different socio-demographic segments when deciding to purchase an electric vehicle in Malta. This study also intends to research the effectiveness of different financial incentives on society and the role of knowledge and awareness in decision making when buying an electric vehicle. The study evolves around the following research questions:

- Are the price and running costs determinant barriers in the uptake of electric vehicles amongst different socio-demographic segments of society?

- Are fiscal incentives an effective means to promote the change from internal combustion engine vehicles to electric vehicles?

- Is knowledge on electric vehicles being marketed in an effective manner to promote a positive attitude towards electric vehicles amongst the general public?

The objectives are to:

- compare trends, patterns and any differences in attitudes with studies performed by other researchers.

- study the attitudes among different socio-demographic segments which influence decision-making when purchasing an electric vehicle.

- perceive which type of financial and non-financial incentives can be effective in influencing the people's attitudes towards electric vehicles.

- establish which demographic segments in society should be targeted in order to have an effective electric vehicle marketing campaign for the coming future.

- recommend what type of incentives and campaigns can be effective in convincing people to buy an electric vehicle.

A deductive approach was adopted following the model of thinking displayed in Figure 3.1. When performing a deductive approach, the researcher tests a theory by formulating a hypothesis or research questions. In the study the researcher has to define the variables associated with the hypothesis or research questions which are in turn measured or observed utilising an instrument. The results obtained are used by the researcher to approve or disapprove the theory (Cresswell, 2009).

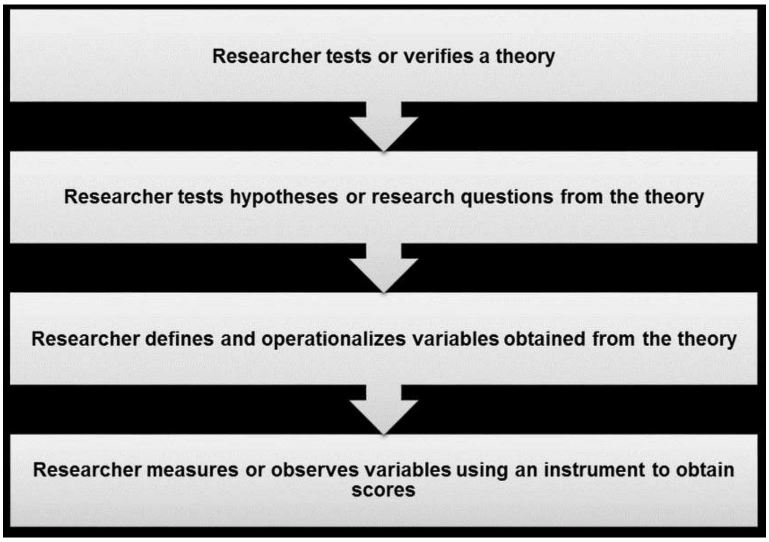

Figure 3.1: The deductive model of thinking.
Source: (Creswell and Creswell, 2017)

3.2. Background to the Methodology

Studies related to the adoption of electric vehicles are generally economic studies or psychological studies (see Tables 3.1, 3.2 and 3.4). Discrete choice analysis is the most utilised methodology in economic studies in which the choice of electric vehicles is considered as an option among a number of vehicle alternatives based on specific characteristics or attributes. Economic studies estimate the weight of different parameters for vehicle attributes in decision making (Liao et al., 2017). Psychological studies, on the other hand, focus on perceptions and psychological constructs such as attitudes and emotions in order to uncover their influence on the adoption of electric vehicles. However, psychological studies tend to ignore the choice among different vehicle options (including ICE vehicles) and do not account for variations in the attributes towards electric vehicles. This limitation provides a restricted understanding of how variations in electric vehicle attributes can influence consumers' preferences for electric vehicles (Liao et al., 2017).

Electric vehicle adoption is influenced by different preferences amongst different vehicle drivers and the process of behaviour change. Drivers are in different stages of change in the adoption of electric vehicles and their attitudes towards electric vehicles and sustainable transport varies depending on where they reside and their needs. However, electric vehicle policy incentives do not focus on a specific target group but target all drivers (Langbroek et al., 2016). Since the implications of policy incentives vary between different groups of drivers (Langbroek et al., 2016), various electric vehicle demand studies, as illustrated in Table 3.3, adopted some form of stated preference analysis (Hidrue et al., 2011). The unit of analysis in these studies was the individual or the household (Louviere et al., 2000).

Electric vehicle purchase behaviour among consumers in different countries is likely to differ due to differences in urban and transport system characteristics (Hoen and Koetse, 2014). Liao et al. (2017) review of 26 studies performed between 2005 and 2015 based on stated preference data identified how infrastructural, technical and financial attributes are determinant attributes that influence the choice of electric vehicles. The review also showed that financial incentives such as tax reduction and purchase incentives are effective measures, but the effectiveness of non-economic incentives such as free parking, access to high occupancy lanes and toll discounts are debatable. Furthermore, no clear patterns emerged from socio-demographic studies related to age, gender, education, income, and household composition since the results obtained differed. Therefore, it is necessary to carry out country-specific experiments since stated choice results of a specific country cannot be applied to other countries (Bera and Maitra, 2021). Furthermore, it is more appropriate to study a country for a specific period than comparing a number of countries at once since the market varies from one country to another (Kim and Heo, 2019).

EV attributes		Hackbarth and Madlener (2013)	Hackbarth and Madlener (2016)	Junquera et al. (2016)	Qian et al. (2011)	Qian et al. (2019)	Helveston et al. (2015)	Ewing and Sarigollu (2000)	Danielis et al. (2020)	Li et al. (2020)	Nie et al. (2018)	Bera and Maitra (2021)
Country		Germany	Germany	Spain	China	China	USA, China	Canada	Italy	China	China	India
Economic	Purchase price	x	x	x	x	x	x	x	x	x	x	x
	Running / fuel / Maintenance costs	x	x		x	x	x	x	x	x	x	x
	Depreciation									x		
	Battery warranty									x		x
Performance	Driving range	x	x	x	x	x		x	x	x	x	x
	Acceleration						x	x				
	Emissions	x	x					x			x	x
Practicability	Charging time	x	x	x		x	x	x	x	x	x	x
	Charging stations (Home/Public)				x	x				x		x
Make & Model	Brand						x			x		
	Size											
	Body type						x					
Incentive policies	Tax exemption / subsidies	x	x		x	x				x		
	Free / Cheaper parking				x				x	x		
	Preferential parking	x	x									
	Preferential driving lanes	x	x		x							

Table 3.1: Electric vehicle attributes studied in stated preference surveys in economic studies.
Source: Compiled by author

EV Attributes		Guerra and Daziano (2020)	Hidrue et al. (2011)	Potoglou and Kanaroglou (2007)	Gong, et al. (2020)	Tanaka et al. (2014)	Jung et al. (2021)	Lebeau et al. (2012)	Hoen and Koetse (2014)	Giansoldati et al. (2020)	Rahmani and Loureiro (2019)
Country		USA	USA	Canada	Australia	USA, Japan	Korea	Belgium	Netherlands	Italy	Spain
Economic	Purchase price	x	x	x	x	x	x	x	x	x	x
	Running / fuel / Maintenance costs	x	x	x	x	x	x	x	x	x	
	Depreciation										
	Battery warranty										
Performance	Driving range	x	x		x	x	x		x	x	
	Acceleration		x	x			x				
	Emissions		x	x		x		x			x
Practicability	Charging time	x	x		x		x		x		
	Charging stations (Home/Public)				x	x	x	x		x	
Make & Model	Brand							x			
	Size			x							
	Body type				x						
Incentive policies	Tax exemption / subsidies				x						
	Free / Cheaper parking	x		x	x						
	Preferential parking	x									
	Preferential driving lanes			x	x						

Table 3.2: Electric vehicle attributes studied in stated preference surveys in economic studies.
Source: Compiled by author

Author	Country	Method of data collection	Survey design	Regression Model
Hackbarth and Madlener (2013)	Germany	Online survey	Stated preference	Mixed logit (MXL)
Hackbarth and Madlener (2016)	Germany	Online survey	Stated preference	Multinomial logit (MNL), Latent class (LC)
Junquera et al. (2016)	Spain	Online questionnaire	Stated preference	Logit
Qian et al. (2011)	China	Online survey	Stated preference	Multinomial logit (MNL), Nested logit (NL)
Qian et al. (2019)	China	Online survey	Stated preference	Mixed logit (MXL)
Helveston et al. (2015)	USA, China	Online survey	Stated preference	Multinomial logit (MNL), Mixed logit (MXL)
Ewing and Sarigollu (2000)	Canada	Focus groups, mail survey	Stated preference	Multinomial logit (MNL)
Danielis et al. (2020)	Italy	Online interviews	Stated preference	Multinomial logit (MNL), Random parameter logit (RPL)
Li et al. (2020)	China	Online survey	Stated preference	Random parameter logit (RPL)
Nie et al. (2018)	China	Face-to-face interviews	Stated preference	Multinomial logit (MNL), Random parameter logit (RPL)
Bera and Maitra (2021)	India	A computer assisted personal interview	Stated preference	Mixed logit (MXL)
Guerra and Daziano (2020)	USA	Online survey	Stated preference	Mixed logit (MXL), Latent class (LC)
Hidrue et al. (2011)	USA	Online survey	Stated preference	Latent class (LC)
Potoglou and Kanaroglou (2007)	Canada	Online questionnaire	Stated preference	Nested logit (NL)
Gong, et al. (2020)	Australia	Online questionnaire	Stated preference	Latent class (LC)
Tanaka et al. (2014)	USA, Japan	Online questionnaire	Stated preference	Error component multinomial logit (ECML)
Jung et al. (2021)	Korea	Online questionnaire	Stated preference	Hybrid Choice (HC)
Lebeau et al. (2012)	Belgium	Online questionnaire	Stated preference	Hierarchical Bayes (HB)
Hoen and Koetse (2014)	Netherlands	Online questionnaire	Stated preference	Mixed logit (MXL)
Giansoldati et al. (2020)	Italy	Online, face-to-face, written interviews	Stated preference	Hybrid Choice (HC)
Rahmani and Loureiro (2019)	Spain	Online survey	Stated preference	Latent class (LC)
Ferguson et al. (2018)	Canada	Online survey	Stated preference	Latent class (LC)
Zhang et al. (2011)	China	Face-to-face questionnaire	Stated preference	Binary Logit (BL)
Higgins et al. (2017)	Canada	Online survey	Stated preference	Multinomial Probit (MNP)
Zhuge and Shao (2019)	China	Paper-based questionnaire	Stated preference	Multinomial logit (MNL)

Table 3.3: An overview of economic studies related to electric vehicle adoption.
Source: Compiled by author

Author	Country	Method of data collection	Psychometric scale	Mode of analysis
Graham-Rowe et al. (2012)	United Kingdom	Semi-structured interview		Grounded-theory analysis
Egbue and Long (2012)	United States	Online questionnaire	4-point Likert scale	Chi-squared analysis
Barth et al. (2016)	Germany	Two preliminary interviews followed by an online questionnaire	7-point Likert scale	Hierarchical regression analysis
Burgess et al. (2013)	United Kingdom	One-to-one interviews		Thematic Analysis
Dogan and Ozmen (2019)	USA, India	Online questionnaire	7-point Likert scale & Self-Construal Scale using a 7-point scale	Confirmatory factor analysis
Liu et al. (2019)	China	Questionnaire	5-point Likert scale	Regression analysis
Nayum et al. (2016)	Norway	Online questionnaire	7-point Likert scale	Latent class cluster analysis
Philipsen et al. (2016)	Germany	Online questionnaire	6-point Likert scale	
Schmalfuss et al. (2017)	Germany	Online questionnaire	6-point Likert scale	Path Analysis
Simsekoglu (2018)	Norway	Online questionnaire	5-point Likert scale	Principal component analysis
Skippon and Garwood (2011)	United Kingdom	Questionnaire	5-point Likert scale	Hierarchical cluster analysis

Table 3.4: An overview of psychological studies related to electric vehicle adoption.
Source: Compiled by author

3.2.1. Revealed preference (RP) and stated preference (SP) survey approach

The Revealed Preference (RP) survey approach is based on a current scenario and current market equilibrium. Therefore, the respondents' choices reflect his/her actual behaviour since choices reflect circumstances and situations experienced or observed by individuals during the current scenario. Revealed preference data produces one observation per respondent at a specific period based on existing attributes and alternatives. Therefore, revealed data is highly reliable and effective in marketing and decision making (Louviere et al., 2000). Yet, most studies on electric vehicles utilised stated preference methodologies due to the availability of limited electric vehicle data (Kim and Heo, 2019). Stated preference surveys are surveys based on hypothetical scenarios which do not exist during current situations but serve in studying how individuals' behaviour changes according to different situations. Few studies on electric vehicles that collected revealed preference data were performed by Wang et al. (2019), Kim et al. (2017) and Sierzchula et al. (2014). These studies did not focus on one country but performed comparisons between different countries where electric vehicles are mostly deployed. Mersky et al. (2016) and Wee et al. (2018) performed two studies that utilised revealed preferences in Norway and USA respectively. Since both countries are leaders in the electric vehicle market, a revealed preference survey is likely to gather reliable and comprehensive data (Kim and Heo, 2019).

The stated preference (SP) survey approach was utilised in various studies to identify factors affecting the purchase of electric vehicles (Jia and Chen, 2021; Rezvani et al., 2015; Singh et al., 2020; Liao et al., 2017; Li et al., 2017; Coffman et al., 2017). This approach is popular when studying electric vehicle adoption due to the limited electric vehicle purchase data (Jia and Chen, 2021) as a result of the small market share of BEVs in the current scenario. Thus, it is very difficult to target BEV users and collect revealed preference (RP) data on their choices (Jin et al., 2020). Stated preference surveys utilise a wide range of scenarios that may not exist under the current scenario to enhance the context of current scenario with alternative specific attributes (Jin et al., 2020). This approach facilitates the identification of population segments who have a positive attitude in adopting electric vehicles, facilitating marketing strategies (Hidrue et al., 2011; Ferguson et al., 2018; Kormos et al., 2019). Furthermore, electric vehicle stated preference studies help in identifying the consumers' perception on electric vehicle related attributes, facilitating decision making, planning and development investment (Wood et al., 2017). The inherent hypothetical bias is the main limiting factor of the stated preference approach, since the stated interests of the respondents might not necessarily reflect their true real-world behaviour (Train, 2009). Any findings of the stated preference study cannot be compared to real world behaviour due to restricted revealed preference data in the field. This limitation can have an impact on a decision maker's confidence in policy implications (Jia and Chen, 2021).

To obtain reliable results from stated preference surveys, fair knowledge among the respondents on the choice context and the alternative attributes is important so that the respondents will be able to perform realistic comparisons and obtain a reliable evaluation. Since consumers tend to have limited experience on electric vehicles, there is the tendency that they have an inaccurate perception about different electric vehicle concepts (Hardman and Tal, 2016; MacInnis and Krosnick, 2020; Long et al., 2019; Krause et al., 2013; Caperello and Kurani, 2012).

Contrasting views are evident in literature regarding the stability of preferences (de Andrés Calle et al., 2020). Certain studies identify stable preferences while others have a contradictory opinion (Danielis et al., 2020). It is incorrect to assume stable preferences over time since electric vehicles are relatively unfamiliar to most consumers and the adoption of electric vehicles depends on the consumers' acceptance of the innovation. Moreover, consumers' preferences and familiarity with electric vehicles are likely to evolve together with technological development, electric vehicle markets and social influence (Liao et al., 2017). Thus, consumers' real-life experience influences attitudes and preferences towards electric vehicles (Jensen et al., 2014).

3.3. Primary data collection

After considering the literature and the aim and objectives of the study, it was decided to collect primary data utilising a quantitative approach, by conducting field surveys. Field surveys study an array of situations, beliefs, and practices using questionnaires or structured interviews. Different variables are measured, and their effect is analysed utilising statistical techniques

(Cresswell, 2009; Lakshman et al., 2000). The term ‘variable’ in research is utilised by social scientists in order to refer to an attribute or a characteristic that varies from one individual to another, which can be observed and measured. The variables that cause or influence the outcomes are called independent variables and the outcomes which are influenced by the independent variables are called dependent variables (Agresti, 2007; Cresswell, 2009). When cross-sectional field surveys are performed, both the independent and dependent variables are studied at a particular period of time. On the other hand, longitudinal field surveys study the relationship between the independent and dependent variables over a period of time. Field surveys are effective because a number of variables can be captured and studied from different perspectives or by utilising different theories.

This study examines the following socio-demographic discrete variables as independent variables: gender, age, level of education, employment, income, level of environmental concern, car ownership and household size. According to literature (see Table 3.5) these independent variables condition consumer behaviour when purchasing electric vehicles, which was considered as being the dependent variable. Adopting a cross-sectional study helps in identifying which discrete independent variables are most influential during the current scenario in the Maltese Islands, thus suggesting which socio-demographic segment should be targeted to promote effective policies and marketing strategies.

Socio-demographic attributes		Hidrue et al. (2011)	Bjerkan et al. (2016)	Plötz et al. (2014)	Mohamed et al. (2016)	Egbue and Long (2012)	Sovacool et al. (2018)	Jia and Chen (2021)	Vassileva and Campillo 2017	Yang et al. (2017)	Morton et al., 2017	Christidis and Focas, 2019
Country		USA	Norway	Germany	Canada	USA	Scandinavian peninsula, Denmark, Iceland	USA	Sweden			
Age	Age group (years)	18 - 35	36 - 55	41–50	Young	x	30 – 45	>35	40 – 45			
	Not significant									x		x
Gender	Males	x	x	x	x	x	x	x	x			
	Females											
	Not significant									x		x
Employment	Are employed			x	x		x	x			x	
	Not significant											x
Income	Low									x		
	High		x	x			x		x		x	x
	Not significant				x	x	x					
Education level	Low											
	High	x	x	x	x	x	x	x	x		x	x
	Not significant									x		
Household type	House								x			
	Apartment											
	Not significant	x			x							
Household size	Single-person											
	Multi-person			x			x	x	x	x		
	Not significant				x							
No. of vehicles per household	Single-car											
	Multi-car						x	x	x			
	Not significant	x								x		x
Pro-Environment		x		x	x		x	x	x	x	x	

Table 3.5: An overview of the socio-demographic attributes influencing electric vehicle adoption.
Source: Compiled by author

3.3.1. Questionnaire surveys

Questionnaires consist of a set of questions and are commonly used in quantitative studies in order to collect data and analyse the sample numerically. This research instrument is ideal to gather data from a lot of people and to measure frequencies related to specific variables namely opinions, experiences, attitude, behaviour and processes. The advantage of gathering information from a lot of people makes questionnaires ideal to profile a population (Rowley, 2014). When compared to interviews in which interviewers ask questions, questionnaires are self-completed by the respondent who has to read and answer each questions alone. Thus, it is fundamental that questions follow an easy structure so that the respondent does not encounter issues when answering the questions (Roopa & Rani, 2012).

Questionnaires can be delivered to potential respondents by post, online or by hand (Rowley, 2014). Questionnaires delivered by post, are costly (Junquera et al., 2016) and tend to have a low response rate (Skipper, 2007). Baruch (1999) estimated that paper-based surveys have an average response rate of 55.6%. Yet, the response rate can be improved to about 70% by paying attention to the questionnaire's design (Dillman, 2011). Online or web surveys are the most recent type of questionnaire survey where potential respondents can answer the survey by accessing a link. The link can be shared utilising email (Cobanoglu et al., 2001) or by means of social media such as Facebook and LinkedIn (Junquera et al., 2016), helping email and web surveys to cover a larger population sample (Dillman, 2000). Thus, the distribution of online surveys is cheap, and the results are recorded immediately on an online database (Evans and Mathur, 2005; Selm and Jankowski, 2006; Ball, 2019). Furthermore, online surveys have a higher response rate when compared to those sent by post even when incentives are not offered to the respondents (Baruch and Holtom, 2008). Nonetheless, when compared to paper-based surveys, web-based surveys are subject to a higher risk of biases, if online surveys are accessed mainly by younger groups who are more inclined to using new technologies. Such situation reduces the representativeness of the sample being studied (Junquera et al., 2016; Zhuge and Shao, 2019). To minimise this issue, in-person surveys can be performed, but these are time consuming and necessitate trained personnel (Ahn et al., 2008). If the need arises, in-person surveys allow space for clarifications (Zhang et al., 2011), which is not possible with online questionnaires. Thus, the set questions in an online questionnaire should not be complex (Robson, 2011). In-person survey responses can be susceptible to socially desirable bias due to in-person contact (Heerwegh, 2009). The respondent might not give a true response but a socially desirable answer, affecting the internal validity of the survey (Bhattacherjee, 2012). Socially desirable bias can be reduced if the respondent trusts the individual carrying out the in-person survey (Holbrook et al., 2003). Nonetheless, although online surveys involve no in-person contact, such surveys can still be subject to socially desirable bias (Wakita et al., 2012) if respondents are afraid of hackers and of the possibility that the survey is intercepted before reaching its destination (Corritore et al., 2003). Thus, if online questionnaire surveys are anonymous, there is a higher tendency that respondents answer the questions sincerely (Sovacool et al., 2018), reducing also early survey drop-out rate (O'Neil et al., 2003).

An advantage of online surveys is that the question sequence in web-based surveys is controlled by the software. Thus, respondents participating in such surveys are capable to focus more on the questions (Potoglou and Kanaroglou, 2007). Yet, online questionnaire surveys can be subject to multiple submissions which can compromise the results obtained; thus, it is important that the survey is designed in a way that prevents this. The major problem related to online questionnaires is that it is not accessible to people who do not own a computer or smart phone, or who do not have access to the internet. In order not to exclude potential respondents, which can undermine the representativeness of the sample (Potoglou and Kanaroglou, 2007), researchers adopt dual-media surveys (physical copy and online) so that potential respondents opt for their preferred method of response (Bhattacherjee, 2012). Although a high response rate increases the representativeness of the sample under study (Cobanoglu et al., 2001), the researcher has also to account for unreturned (Rylander et al., 1995) or incomplete questionnaires (Meyerhoff et al., 2014) with missing data which result to be unusable for the study (Baruch, 1999). Therefore, the value of study is highly influenced by the response rate (Baruch and Holtom, 2008) which tends to be low if the wrong recipient is targeted or if the targeted population is reluctant to participate in the research (Baruch, 1999; Rogelberg and Stanton, 2007) especially if not interested in the topic under study (Groves et al., 2004; Galesic, 2006).

3.4. Field survey design reflecting the Maltese context

An understanding of the attributes and what motivated early electric vehicle adopters to purchase these vehicles, helps in setting up effective policies and market strategy plans. Studying early adopters helps in identifying potential electric vehicle purchasers (Berliner et al., 2019). However, it is difficult to target only early users because the market share of electric vehicles in the Maltese Islands is still low in numbers. By the end of June 2023, the stock of BEV and PHEV vehicles composed only 3.3%, that is 14,336 out of 432,039 vehicles of the total vehicle stock (NSO, 2023a). This limitation makes it very difficult to study the various attributes of electric vehicle owners in the Maltese market, in the same way as it was done in different economic studies in other countries. Due to the mentioned limitations a revealed preference survey based on actual choices will not be effective. On the other hand, a stated preference survey which presents a wider scenario based on non-existing alternatives and situations suites this study well (Jin et al., 2020). The hypothetical scenarios presented in the stated preference survey will facilitate the understanding of the perceptions and attitudes of different socio-demographic segments in different circumstances. This understanding will in turn facilitate effective recommendations related to policy making and marketing strategies.

Various studies related to electric vehicles were based on cross-sectional data. Lieven (2015), Plötz et al. (2017), Plötz et al. (2016) and Sierzchula et al. (2014) collected cross-sectional data on a country level. And while Vergis and Chen (2015) and Jin et al. (2014) gathered cross-sectional data on a state level, Slowik and Lutsey (2017), Wang et al. (2017), and Mersky et al. (2016) obtained cross-sectional data on a city level. Since the electric vehicle market in the Maltese Islands is still in its initial phases, the attributes that motivate Maltese buyers to opt for electric vehicles are still unclear. Although the consumers' behaviour evolves due to developments in technology, changes in the electric vehicle market and social influence (Liao et al. 2017), it is important to study the current scenario. Thus, a cross sectional study utilising a stated preference survey approach which considers all socio-demographic segments is appropriate to observe and analyse current trends related to the adoption of electric vehicles in Malta.

3.4.1. Research approach

Tables 3.3 and 3.4 show how online questionnaire surveys are the most common means of data collection in literature in both economic and psychological fields related to electric vehicle adoption. After considering all data collection options, it was decided to opt for online questionnaire surveys as the main data collection method. However, to avoid any risk of biases and give equal possibility to all potential respondents, paper-based questionnaires were also considered, not to exclude individuals who do not have access to a computer or smart phone or the internet. In order to avoid social desirability bias responses which, undermine the validity of the data collected, face-to face questionnaires were not considered since such a method does not grant anonymity, thus contributing in an increase in the possibility of not obtaining truthful answers. In the questionnaire introductory note, participants were informed that participation was on a voluntary basis and that their identity was going to remain anonymous. Participants were also able to withdraw from the questionnaire at any time, so that the data collected would be gathered from participants who are willing to declare accurate information.

In research, it is not possible to study the whole population due to financial limitations, thus a representative sample is utilised by the researcher. Selecting a representative sample is essential to avoid incorrect conclusions. In the first phase of the sampling process, the target population is identified and a sampling frame is chosen. The sampling frame refers to the section of the targeted population from which a sample can be drawn and studied (Ishak and Abu Bakar, 2014). Since currently in the Maltese Islands the number of electric vehicle adopters is low it is unlikely to identify a specific segment in society that is keener in adopting electric vehicles. Therefore, the author’s sample included people of 18 years and older from different socio-demographic segments residing in the Maltese Islands, both with and without a driving licence. Respondents with a driving licence included both those individuals who already own an electric vehicle and also those who do not. Individuals who do not own a driving licence or have a driving licence but do not own a vehicle were also given the opportunity to participate in the study to investigate the perception of non-vehicle owners with regard to the purchase of electric vehicles. Knowing EV perception among non-vehicle owners is also important because their perceptions and opinions can still have a determinant role on the behaviour of drivers when deciding about EV adoption Furthermore, this demographic segment can represent potential future drivers.

3.4.2. Identifying a representative sample

To determine a representative sample population size for the study, reference was made to an online sample size calculator (calculator.net, 2022) utilising a 95% confidence level and a margin of error of 5%. The sample size population was based on figures published in NSO (2021c). Since the published figures incorporated 18 and 19 year old individuals in the 10 - 19 year age group (see Table 3.6), this made it impossible to identify the exact number of individuals that had 18 and 19 years by the end of 2019. Therefore, in order to avoid assumptions and calculate the sample size population on official NSO figures, it was decided to exclude the 18 and 19 year individuals when using the online sample size calculator. Due to this fact, the calculation was performed considering the total population aged 20 years and over by the end of 2019 which totalled 423,260 people, thus obtaining a sample population size of 384 people. Despite excluding NSO figures associated with 18 and 19 year individuals, the sample size obtained was considered reliable because when maintaining a 95% confidence level and a margin of error of 5%, the sample size calculator provides the same sample population size of 384 up till a population size of 950,000. A population size of 950,000 is by far larger than the total population of the Maltese Islands which is around 519,562 (NSO, 2022a), thus, the sample population size of 384 was considered representative.

Age group	Males	Females	Total
0-9	24,486	22,786	47,272
10-19	22,700	21,332	44,032
20-29	42,896	36,082	78,978
30-39	48,450	40,451	88,901
40-49	37,503	32,552	70,055
50-59	30,635	28,533	59,168
60-69	29,646	29,905	59,551
70-79	21,139	23,779	44,918
80-89	7,390	11,250	18,640
90+	917	2,132	3,049
Total	265,762	248,802	514,564

Table 3.6: Total population of the Maltese Islands by age group by the end of 2019

Source: NSO (2021a)

After considering both probability sampling and non-probability sampling techniques, the author opted for simple random sampling which is a type of probability sampling technique. In probability sampling, every unit in the sample has an equal chance of being selected (Shorten and Moorley, 2014) while in non-probability sampling certain units in the sample have zero chance to be selected (Elfil and Negida, 2017).

3.4.3. Ethical review procedures

Data collection in the study involved the participation of humans, thus it was essential to follow ethical procedures before gathering the relevant data for the research. Ethical procedures are fundamental to ensure confidentiality and safeguard the wellbeing of the individuals participating in the study (De Wet, 2010). The research ethics and data collection form was submitted to the Faculty of Arts Faculty Research Ethics Committee (FREC) for review. The form required a brief description of the study as well as information about the collection and storage of primary data from the participants. Furthermore, the form also considered that the participant's identity was going to be protected by guaranteeing anonymity and ensuring that participants were not subject to any hazard during data collection. Ethics approval with the reference ARTS-2022-00185 was obtained on 18th August 2022. The author also informed the participants in the questionnaire's introductory note that the research was in line with the University of Malta Research code of practice and research ethics review procedures.

3.4.4. The expected utility theory and the decision field theory

The expected utility theory and the decision field theory are two theories that aim to explain the respondents' behaviour behind a specific choice, thus giving an understanding on how survey participants act during the process (Galesic, 2006). According to the expected utility theory when the decision-maker has to choose between two uncertain utilities, the individual opts for the utility that in his/her opinion has the highest expected value (Małecka, 2020). Therefore, the expected utility theory assumes that the decision-maker acts rationally by simply weighing the value of each expected alternative before taking a decision (Townsend and Busemeyer, 1995). That is, while going through the survey, the respondent will act in a logical manner by evaluating and opting for the preferred choice without being influenced by the complexity of the choice set or by the survey length (DeShazo and Fermo, 2002). The expected utility theory considers choice preference as being independent from deliberation time (Busemeyer and Townsend, 1993). The decision field theory on the other hand, is a more dynamic theory influenced by psychological principles (Busemeyer and Diederich, 2002) which states that an individual's decision related to a specific choice preference can change during thinking time. Thus, survey respondents' behaviour may be influenced by variables related to the survey design which influence the choice consistency (Chung et al., 2011).

3.5. The research questionnaire design

The questionnaire survey was designed to be completed in around 15 – 20 minutes so that potential respondents perceive minimum cognitive burden, leading to a higher participation rate (Crawford et al., 2001). Attention was given so that the actual survey completion timeframe declared in the survey's introductory note is realistic, to reduce drop-out rate especially among participants who experience cognitive fatigue in the early stages due to lack of interest in the surveyed topic (Galesic, 2006). The questionnaire timeframe is in line with the findings of Revilla and Ochoa (2017) and Revilla and Höhne (2020) whose studies identified that the ideal survey length, whether performed online or not should be between 10 minutes to 15 minutes and that it should not exceed the length of 20 minutes. Since the ideal survey length perception may also be influenced by socio-demographic characteristics (Revilla and Höhne, 2020), the questionnaire design and timeframe were tested by conducting a pilot study among 10 individuals. Pilot studies are small scale studies which serve in testing the survey design and identify from an early stage any shortcomings that might impact data collection when conducting the main investigation (Arain et al., 2010; van Teijlingen and Hundley, 2002; Kistin & Silverstein, 2015). In order to obtain a holistic feedback from the pilot survey and avoiding inaccurate conclusions (van Teijlingen and Hundley, 2002), the sample was composed of young, middle aged people as well as individuals older than 65 years. Furthermore, the individuals participating in the pilot survey sample came from different educational backgrounds. Thus, to facilitate understanding among respondents whose knowledge in the field is limited, acronyms of the three types of electric vehicles mentioned in the survey were explained and a brief overview about the operation of each electric vehicle was given. Additionally, a brief explanation was also provided when mentioning contexts or situations that are currently not present in the Maltese Islands which are not familiar to potential repondents. Following the pilot survey, all participating individuals irrespective of their age and background responded the survey within the 20 minutes timeframe and encountered no issues in understanding the survey questions.

Online data collection was performed utilising the free online survey software "Google Forms" which is composed of a relatively plain template design. Plain designs tend to be more effective in maintaining respondent interest to proceed with the survey when compared to fancy designs that incorporate bright colours and format changes. If respondents take a long time to understand the questions due to the questionnaire design, participants may either fail to complete the questionnaire or give inaccurate answers influencing negatively the validity of the data collected (Dillman et al., 1998). Web surveys designed in a fancy manner can also be subject to long loading times due to the consumption of considerable computer memory (Dillman et al., 1998; Couper et al., 2001) and extra pressure on the internet server (Crawford et al., 2001). In such cases, drop-out occurs in the initial stages of the questionnaire (Heerwegh and Loosveldt, 2002). The online questionnaire link was later shared on Facebook and via email in order to be accessible to an array of potential respondents living in all the six districts in the Maltese Islands. To avoid biases, apart from posting the link on my personal Facebook profile, the link was also posted on different pages in order to reach a variety of respondents from different backgrounds. Furthermore, the link was shared on Facebook and via email by friends and relatives, helping me to gain a wider perspective. On the other hand, paper-based questionnaires were provided to those individuals who made such a request.

The questionnaire survey was designed utilising mainly close-ended questions. The close-ended questions in the questionnaire survey were all compulsory questions, thus any participant who opted to drop-out from the survey was not able to submit the survey. This measure avoided the reception of incomplete questionnaires which would not have been useful for the study, thus would eventually be discarded. Open questions can cause a high drop-out rate since answering open questions involves more effort in thinking and typing the response (Crawford et al., 2001; Galesic, 2006). Therefore, in order to reduce respondent fatigue, the questionnaire should have few open questions (Bryman, 2012) and the inclusion of taxing questions should be done intermittently among less demanding questions (Galesic, 2006). Due to this fact, the survey questionnaire designed for this study included only one open ended question in the very end of the survey. The question asked respondents to mention suggestions which could be implemented in order to increase electric vehicle adoption in the Maltese Islands. The question was not a compulsory question in order to account for those respondents who might have no recommendations, and consequently see no necessity to answer the question. Responses to this open-ended question served in collecting unexpected qualitative data which would not be collected with closed questions, allowing a deeper insight of the situation under study (Bhattacherjee, 2012).

The questionnaire survey (see Appendix A) was designed in three main sections, and questions were grouped according to the aspect being studied in order to help respondents focus on the questions and avoid confusion (Courage and Baxter, 2005). Questions were grouped in the following sections:

(i) Socio-demographic characteristics
(ii) Assessing consumer attitude towards electric vehicle adoption using Likert scales
(iii) Evaluation of consumer preferences through a stated choice experiment

3.5.1. Socio-demographic characteristics

Socio-demographic questions in a questionnaire survey gather demographic information of the participants in order to define the background characteristics of the respondents (Ziegenfuss et al., 2021). This section includes questions on age, marital status, place of residence, employment status, property type, number of vehicles in the household and the budget spent when buying a vehicle. The collection of demographic information was fundamental for this study in order to assess the influence of different independent socio-demographic variables towards electric vehicle adoption. Therefore, this section proves to be essential in answering the research questions and establish trends and patterns among Maltese society that reflect current scenario. Furthermore, the information gathered in this section, will make it easier to identify similarities and differences with other studies in the field, facilitating other researchers to replicate the study (Hughes et al., 2016).

Literature shows conflicting opinions regarding the placement of demographic questions in a questionnaire survey (Teclaw et al., 2012). Dillman (2011), Jackson (2009) and Bourque and Fielder (2003) state that demographic questions should be included at the end of the questionnaire to avoid drop-outs due to sensitive questions. Contrasting findings were presented by Drummond et al. (2008) and Frick et al. (2001) who state that the inclusion of demographic questions in the beginning of the questionnaire can lead to a higher response rate and lower drop-outs (Frick et al., 2001). On the other hand, Green et al. (2000) found that including demographic questions in the beginning or in the end of the questionnaire did not influence the response rate.

Considering that socio-demographic information is an important part in this study, as suggested by Gilovich et al. (2006), demographic questions were included in the beginning of the questionnaire. The set questions required no sensitive data and were all close ended in multiple choice format. Initiating a questionnaire with straightforward questions also reduces the risk of participants getting discouraged from answering the following more complex questions (Courage and Baxter, 2005). Furthermore, since the demographic questions are posing no threat to confidentiality, there is a lower risk that respondents opt not to participate in the survey (Hughes et al., 2016), skip the questions (Lor et al., 2017) or drop-out from the survey (Singer et al., 1992). Considering that certain individuals consider age as being sensitive information, age ranges were utilised to avoid discomfort among individuals when responding to the age-related demographic question (Albert et al., 2009; Colton and Covert, 2007). Moreover, considering that a question on income is also considered as a sensitive question (Nuno and St. John, 2015; Tourangeau and Yan, 2007) that can lead to high non-response rates (Krumpal, 2011), the questionnaire did not request participants to declare their income. However, since income is one of the attributes which according to studies determines electric vehicle adoption (see Table 3.5), respondents were asked to identify the budget usually spent when purchasing a vehicle. Similar to the age-related question, price ranges were utilised to reduce any possible discomfort. Avoiding sensitive questions in the questionnaire design can also increase the chance of obtaining more accurate responses (Tourangeau and Yan, 2007).

3.5.2. Assessing consumer attitude towards electric vehicles using Likert scales

The Likert scale is a common psychometric rating tool utilised in psychological studies to quantify psychological and personal attributes (Xu and Leung, 2018). The scale is characterised by a series of statements about a specific topic which are rated by participants utilising a scale. Following data collection, the results are processed by assigning a number to each scale category (Józsa and Morgan, 2017). As illustrated in Table 3.4 the Likert scale is widely used in psychological studies related to electric vehicle adoption, where researchers applied the tool in both paper-based (Liu et al.,2019; Skippon and Garwood, 2011) and online (Egbue and Long, 2012; Dogan and Ozmen, 2019; Nayum et al., 2016; Barth et al., 2016; Philipsen et al., 2016; Schmalfuss et al., 2017; Simsekoglu, 2018) questionnaire surveys to gather data. Likert scale designs vary among researchers because designs are tailormade to cater for the abilities and experiences of the targeted sample (Hartley and Betts, 2010). However, it is also important to note that the results obtained are also influenced by scale format and by the question style used (Denscombe, 2009; Dillman and Christian, 2005) which unknowingly manipulate the respondent's opinion about the topic under study (Hartley and Betts, 2010).

Likert scale formats differ with regard to the number of response categories, type of labelling and whether the choice category is designed utilising an even or an odd number (Weijters et al., 2010). However, it is crucial that the distance between the scale categories is equal in order to produce accurate information related to the psychological and personal attributes being studied (Wakita et al., 2012). Literature indicates that there is no common agreement among researchers regarding the ideal number of Likert scale categories utilised to rate attributes (Alwin, 1992; Maydeu-Olivares et al., 2009; Wakita et al., 2012; Ilhan and Neşe, 2017), yet past studies indicate that the Likert scale categories adopted range from a format of four categories to eleven categories (Xu and Leung, 2018).

Formats with five, six and seven categories are the most popular formats adopted by researchers (Weijters et al., 2010), including those related to electric vehicle adoption (see Table 3.4). Although having a larger number of scale categories is more time consuming (Wakita et al., 2012), the use of many scale categories can increase the reliability and validity of the data collected (Weng, 2004; Lozano et al., 2008; Preston and Colman, 2000; Tarka, 2015).

However, contrasting results were obtained by Lueng (2011) and Wakita et al. (2012) who compared an eleven category scale with four, five and six category scales and by Dawes (2002) who compared an eleven category scale with a five category scale. The authors found no correlation between the number of scale categories and reliability, but Dawes (2002) stated that although both eleven and five scale categories provided the same data, the data obtained from the eleven scale category had a higher coefficient of variation. After comparing three, five, seven and nine category scales, Kim (1998) concluded that validity and reliability was highest in the five and nine category scales and lowest in the three category scale. Therefore, scales with less than five categories are not recommended because limited response categories do not permit participants to adequately express themselves (Weng, 2004). However, the inclusion of a lot of categories may result in a higher risk that the respondents utilise only part of the scale (Alwin and Krosnick, 1985). Thus, it was decided to design five category Likert scales for this study taking also into account that a sizeable number of categories may lead to a reduction in the goodness of fit (Maydeu-Olivares, 2009). The goodness of fit is a test that evaluates the adequateness of statistical models in providing valid data and in avoiding incorrect results which impact negatively the final analysis (Pinto and Sooriyarachchi, 2021).

Using an odd number of categories (five-point scale) allowed respondents to opt for a mid-point neutral option in the scale that ranged from 'strongly disagree' to 'strongly agree' (Allen and Seaman, 2007; Lueng, 2011; Wakita et al., 2012). On the other hand, a neutral option would not have been available if an even number of categories such as in the case of four and six category Likert scales (Lueng, 2011) was adopted. A disadvantage associated with the inclusion of a neutral mid-point option is that the option can be utilised by individuals who are uncertain or lack interest in choosing a significant response. Therefore, in such cases, the data obtained in relation to the mid-point category will not represent exclusively those participants who have a neutral opinion. Adopting an even number of categories avoids this issue because respondents will be forced to take a specific position. Yet, data collection can still be subject to inaccuracy because participants who have a neutral option will not be able to demonstrate their neutrality (Yorke, 2009). Thus, respondents who are forced to choose an option might get frustrated, resulting in a negative impact on their choice decision which can lead to a high proportion of uncertain respondents to opt for negative answers (Weijters et al., 2010). When comparing a five category and a four category scale, O'Muircheartaigh et al. (2001) noted that the neutral mid-point in a five category scale reduced the incidence of error.

Scale labelling formats include either full labelling, where each scale category is labelled or end labelling where only the two extreme categories are labelled (Weijters et al., 2010). The five category Likert scales in the questionnaire survey were designed with a full label format ranging from "strongly disagree" to "strongly agree". Full label formats give a more detailed and clear direction on how each scale category has to be interpreted, increasing reliability (Johnson et al., 2005; Weng, 2004). Furthermore, cognitive loading is minimised since a fully labelled scale is easier to interpret by the respondents when compared to an end labelled scale (Krosnick and Fabrigar, 1997; Moors et al., 2014). Central categories in a full labelled scale are more notable (Weijters et al., 2010), consequently attracting more responses from participants (Posavac et al., 1997; Posavac et al., 2003). Therefore, fully labelled scales can contribute to higher data validity (Coromina and Coenders, 2006; Krosnick and Berent, 1993), avoiding an excess number of participants opting for extreme labels (Arce-Ferrer, 2006). Furthermore, in end labelled scales, respondents have to interpret unlabelled categories before making the choice, which can be defined differently by different respondents (Arce-Ferrer, 2006; Schaeffer and Presser, 2003). For example, without full labelling, the second category in the Likert scale adopted in the study can be interpreted either as 'slightly disagree' or 'disagree'. Therefore, using fully labelled scales reduces ambiguity when defining each scale category, and strengthens scale category interpretation (Rohrmann, 2007; Weijters et al., 2010). No colour hues were applied to the Likert scale tasks in order to reduce the risk that the shades associated with each scale category lead to a shift in responses towards one end of the scale, especially when participants are uncertain (Tourangeau et al., 2007).

Instead of verbal labelling, scale categories can be labelled utilising numerical figures which grant equal intervals across the scale and overcome the difficulty of identifying adjectives to label the categories, especially when sizeable scale categories are used (Fowler Jr and Fowler, 1995). Since the Likert scale tasks in the questionnaire survey had a five category format, there was no problem in the identification of verbal adjectives for each scale category. Numerical labelling was avoided also because individuals are not used to express their opinion in numbers, therefore respondents may encounter difficulties when expressing their opinion (Krosnick and Fabrigar, 1997). In fact, the interpretation of numbered categories may vary amongst individuals (Moors et al., 2014) due to the abstractness of numerical figures (Maitland, 2009). Schwarz et al. (1991) found that a ten category scale ranging from -5 to +5 was interpreted differently when compared to a ten category scale ranging from 0 to 10. Similar findings were also presented by Tourangeau et al. (2007) who stated that when the term "rarely" is linked to the numerical label 0 instead of 1, there is a lower chance that it is chosen by respondents, because respondents may interpret 0 as "never".

Likert scales can be formulated utilising positively worded or negatively (reversed) worded statements (Hartley, 2014; Gliner et al., 2017). Statements can be negatively worded utilising the term 'not' or an opposite to the positive term (Suárez-Alvarez et al., 2018). Utilising positively and negatively worded statements encourages participants to read carefully each statement, avoiding the risk that participants adopt a specific rating pattern. When computing the responses of negatively worded statements the responses should be 'reversed scored' (Hartley, 2014). Therefore, if the researcher utilises a five category scale, the category labelled 'strongly disagree' should be assigned a value of five while a value of one should be given to the category labelled 'strongly agree' (Józsa and Morgan, 2017). Certain researchers are against the inclusion of negatively worded statements (Hartley, 2014) and reversed statements because it is not easy for the researcher to write corresponding positive and negative statements where opposite words do not exist (Rozin et al., 2010). The author designed the Likert scale including only positively worded statements because negatively worded statements or reversed statements in the questionnaire survey might confuse individuals who have poor reading skills (DeVellis, 2003) especially when performing reverse thinking (Hartley and Betts, 2013; Yorke, 2009).

The questionnaire survey included ten five-category Likert scale sets and each set was composed of four statements (see Appendix A). Respondents had to rate each statement by referring to the labels that ranged from strongly disagree to strongly agree. Considering that during current situations, Maltese consumers are still in the first two stages (knowledge and persuasion) of Rogers' theory about the social process of the diffusion of an innovation, Likert scale sets intended to evaluate whether consumers are developing a positive or a negative attitude towards electric vehicles. Furthermore, Likert scale sets intended to answer the third research question by studying the respondent's extent of knowledge in the field and considered different variables that may influence the consumer attitude towards electric vehicle adoption. Therefore, each Likert scale set tackled a specific attribute which according to international and local literature may influence consumer attitude towards electric vehicle adoption.

As stated in the literature review, electric vehicle experience was low during the scenario when Ahomaa (2018) performed her study but increased at the time when Camilleri (2020) performed his study, therefore Likert scale set 1 serves as a continuation of previous studies performed by Ahomaa (2018) and Camilleri (2020). The set of statements in Likert scale set 1 seeks to identify the most popular type of electric vehicle among HEVs, PHEVs and BEVs during the current Maltese scenario. In fact, Likert scale set 1 assesses consumer perceptions towards the three types of electric vehicles in the Maltese Islands, giving a better picture of the reasons behind the adoption of a specific type of electric vehicle over another. This can confirm or otherwise if Maltese consumers prefer HEVs over PHEVs and BEVs due to similarities of the former with ICE vehicles (Barbara, 2011). The second Likert scale set assesses whether consumers are aware about the existence of economic and non-economic incentives intended to encourage electric vehicle adoption. Ahomaa (2018) and Pisani (2020) found contrasting results on the matter, in fact only the study performed by Pisani (2020) showed that the respondents had a high level of awareness. However, it is important to note that the outcome of the study performed by Pisani (2020) may have been influenced by the restricted sample which was composed only of students attending the University of Malta. In fact, according to literature, electric vehicle adoption is more common among people with high education levels (see Table 3.5). The fact that this current study considers a larger sample population, the outcome of this scale set should be more indicative of the matter, answering also the third research question.

Table 3.5 shows that electric vehicle adopters are often pro-environment. This aspect was studied in Likert scale set 3 where the set of statements considered emissions related to electric vehicle production, running and charging. The fourth Likert scale set considered economic factors, that is the price and operational cost of electric vehicles which according to literature also influence the rate of adoption of such vehicles (see Tables 3.1 and 3.2). Likert scale set 5 compliments Likert scale set 4 because it seeks to understand consumer perceptions towards the purchase of second-hand electric vehicles which are cheaper and more affordable when compared to brand new electric vehicles. However, consumers may hesitate to purchase such vehicles due to concerns related to battery life (see Tables 3.1 and 3.2).

Aside from economic barriers, slow electric vehicle adoption may be due to other concerns such as convenience, range anxiety and safety related to fire risks as well as the possibility of accidents due to low operation sound. The mentioned concerns are investigated in Likert scale set 6. As far as the author is concerned, no research investigates the impact of possible fires triggered by battery failure on electric vehicle adoption. Thus, when designing the fourth statement in Likert scale set 6 related to electric vehicle safety, fire risk was considered as a factor to be included as part of the statement: *"I am concerned about the safety of electric vehicles such as fires or accidents due to low operational sound."* On the other hand, Likert scale set 7 considers constraints related to charging, including charging point availability, distance to the nearest charging station and the length of time taken for the battery to charge (see Tables 3.1 and 3.2). Both Cuschieri (2020) and Barbara (2011) studied the impact of social influence on the decision to purchase or otherwise, an electric vehicle. Since contrasting results emerged, Likert scale set 8 was designed to assess this aspect. This Likert scale set also evaluated if incentives such as free parking or a subsidised Gozo channel ferry fee (to reduce the cost of crossing between islands by car) have an impact on the respondent's opinion on electric vehicle adoption. The last two Likert scales assess the perception of Maltese consumers about the vehicle-to-grid system and battery swapping which may encourage consumers to opt for electric vehicles.

3.5.3. Evaluation of consumer preferences through a stated choice experiment

As seen in Table 3.3 economic studies related to electric vehicle adoption widely utilised survey designs consisting of stated choice experiments. The design of the stated choice experiment requires the researcher to identify the attributes and attribute levels that represent the alternatives from which the respondents have to choose (Rose et al., 2009). Certain studies considered different stated experiment designs to account for cognitive load and fatigue issues which include attribute quantity, the number of alternatives per attribute (Arentze et al., 2003; DeShazo and Fermo, 2002) as well as the set of choices (Hensher et al., 2001). Vicente and Reis (2012) and Meyerhoff et al. (2014) state that drop-out rates are significantly influenced by the survey's length. In fact, a design with 6 choice sets, 4 attributes and 3 alternatives had a much lower drop-out rate when compared to a design with 24 choice sets, 4 attributes and 5 alternatives (Meyerhoff et al., 2014). Similar trends were observed by Carlsson and Martinsson (2008) where response rate declined by 16% from a choice set of 12 to that of 24. On the other hand, other studies concluded that variations in the number of choice tasks resulted in a minimum influence on the response rate in both mail (Hensher et al., 2001) and online (Bech et al., 2011) surveys.

Louviere et al. (2013) confirmed the findings of Hensher et al. (2001) and Bech et al. (2011) but identified a decline in respondents when the choice set gets complex and when the number of alternatives per attribute increases. Questionnaire designs with three attribute alternatives result in lower drop-out rates when compared to attributes with five alternatives (Meyerhoff et al., 2014). Furthermore, too many alternatives influence the choice consistency of the respondents (Arentze et al., 2003; DeShazo and Fermo, 2002). Therefore, in order to overcome drop-out concerns, an online survey should consist of a limited number of choice sets, few attributes (Spencer-Cotton, 2016) and not more than four (Carson et al., 1994) to five (Rose et al., 2009) alternatives per attribute. Moreover, the alternatives for each attribute should be credible and practicable (Bera and Maitra, 2021). Nonetheless, respondents should be given the possibility to rate each attribute on its own because respondents may be discouraged if they have to perform comparisons between a lot of attributes (Meyerhoff et al., 2014). In other instances, when processing too much information, respondents can make mistakes or adopt mental shortcuts (heuristics) based on partial information when making choice decisions (Arentze et al., 2003) increasing error variance (Breffle and Rowe, 2002).

Drop-out can negatively impact the validity of the data collected, however Louviere et al. (2013) stated that although the survey design with 16 choice sets, 6 attributes and 3 alternatives had a 9% higher completion rate when compared to surveys with 32 choice sets, 6 attributes and 5 alternatives, the latter provided 80% more data. Having a number of alternatives per attribute also increases the chance that the respondent finds an option that matches more accurately his/her belief while the researcher obtains a wider range of comparisons (Caussade et al., 2005). Therefore, the association between the number of alternatives and the margin of error has a U-shaped relationship (Caussade et al., 2005; Czajkowski et al., 2014), where an increase in the number of alternatives can reduce the margin of error only to an extent. If the number of alternatives exceeds a certain limit the margin of error will then increase due to boredom (Czajkowski et al., 2014) or increased fatigue (Czajkowski et al., 2014; Caussade et al., 2005; de D. Ortuzar et al., 2000; Bradley and Daly, 1994).

Literature shows no uniformity with regard to the survey design of choice experiments (Bech et al., 2011) since in many studies the survey length, choice sets, and the number of attributes and alternatives were chosen randomly (Chung et al., 2011). The effectiveness of the stated choice design varies from one country to another depending on socio-demographic settings of the country; thus, a stated choice design is not easily transferable from one country context to another (Rose et al., 2009). Therefore, the survey design has to cater for the target population by considering the behaviour of potential respondents with regard to a lengthy survey with a number of choices (Chung et al., 2011). The stated choice design utilised to gather information for the study was composed from a total of nine choice sets to study the role of economic attributes on the purchase behaviour of the Maltese residents. In order to evoke realism and reduce any form of bias during the choice exercise, the author followed the approaches adopted by Hackbarth and Madlener (2013) and Helveston et al. (2015). The author attempted to reduce hypothetical biases (Hackbarth and Madlener, 2013) by requesting participants to consider the stated choice tasks in the exercise as if they were real situations. Furthermore, to reduce biases associated with the vehicle's aesthetics and size (Helveston et al. 2015) that may influence negatively the participants' focus on the attributes presented in the exercise, participants were requested to keep in mind a visually attractive vehicle while answering all the choice tasks. Unlike Helveston et al. (2015), the author did not include vehicle images to avoid a situation where participants are attracted by none of the vehicle options presented, which in turn can increase possible risks of bias.

The first six stated choice experiments were designed with four economic attributes; vehicle price, road licence cost, fuel cost and battery replacement cost for three vehicle alternatives; petrol, diesel and electric vehicle. To avoid the inclusion of a lot of alternatives that may reduce the respondents' focus, the choice experiments included all types of electric vehicles as part of the same alternative. The purpose of these choice experiments was to analyse to which extent economic attributes influence respondents when choosing between the three vehicle alternatives sold on the Maltese market. Thus, the first six stated choice experiments intend to answer both first and second research questions giving an indication of which financial incentive strategies can be effective in promoting an increase in purchase of electric vehicles in the future. Although maintaining the same question design, the data that was included in the stated choice experiment related to each attribute differed from one stated choice experiment to another. When designing the choice experiment the author was aware that in the Maltese Islands both petrol and diesel vehicle owners whose vehicles were registered since 1st January 2009 pay the same road licence fee depending on the vehicle's CO_2 emissions. Though considered a type of electric vehicle, the road licence of HEVs in the Maltese Islands is also evaluated under the mentioned ICE road licence category due to the vehicles' reliance on their in-built internal combustion engine. On the other hand, BEV and PHEV owners pay no licence fee for the first 5 years and from the 6^{th} year onwards pay a fee of €10 (Transport Malta, 2018).

When designing the road licence cost attribute, it was not possible to utilise identical values for both petrol and diesel vehicles because such action would have made the licence cost attribute redundant when processing the data using the Multinomial logit model. Thus, to avoid issues when processing data, different road licence cost values were utilised for petrol and diesel vehicles. However, the value range difference of the road licence cost attribute of both petrol and diesel vehicles was minimal throughout the six choice experiments to reflect as much as possible reality and reduce cognitive burden among respondents.

Hypothetical scenario 1

Although the author was aware that the vehicle's purchase price is susceptible to the brand and attributes, the exercise presented vehicle prices that reflect the value of the most affordable new internal combustion engine and electric vehicles sold on the Maltese market. To identify whether the actual electric vehicle price presents a barrier to consumers, the electric vehicle price presented in hypothetical situation 1 does not incorporate price reductions associated with the government financial incentives. Road licence fees were obtained from Transport Malta (2018). Therefore, the electric vehicle licence fee utilised in the experiment reflects the incentives adopted by the Maltese government to encourage the purchase of such vehicles (BEVs and PHEVs), that is free road licence for the first five years. Although from the sixth year onwards the licence fee charged is that of €10, such information was not included in the choice experiment in order not to overload the experiment with a lot of information which might result in cognitive burden. As regards ICE vehicles, the author referred to the licence fee category relevant to those vehicles registered since 1^{st} January 2009. According to the latter category, both petrol and diesel vehicles with carbon dioxide emissions between 0g/km up to 100g/km pay the lowest licence fee, ranging from €100 to €295 when the vehicle reaches fourteen years on the road. On the other hand, vehicles with carbon dioxide emissions between 101g/km up to 130g/km pay the second lowest licence fee, ranging from €125 to €339 (Transport Malta, 2018). The mentioned ICE vehicle licence fees are the most affordable and consequently the most attractive among consumers, thus the lowest licence values of the abovementioned categories (€100 and €125 respectively) were utilised in the choice task. The inclusion of two different values within the same range helped in maintaining an equilibrium between the licence cost of petrol and diesel vehicles without undermining data processing when using the Multinomial logit Model.

Fuel / charging cost reflect the prices at the time of the study; €1.34 per litre for petrol vehicles, €1.21 per litre for diesel vehicles (Enemed Company Ltd, 2022), €0.1298 per kWh to charge an electric vehicle during off peak hours and €0.1485 per kWh when charging the electric vehicle during on peak hours (Enemalta, 2021). Since fuel cost and charging cost are measured utilising different units, similar to Hackbarth and Madlener (2016) and Danielis et al. (2020) it was decided to present the fuel / charging cost as a value in euro per 100km. Considering that my personal small engine petrol vehicle can perform an average of 13.4km per €1.34, it was assumed that the petrol vehicle's fuel will cost €10 per 100km. Diesel vehicles consume between 15% - 20% less fuel when compared to petrol vehicles (Nagpal, 2022), thus it was assumed that the diesel vehicle's fuel will cost €8 per 100km. A number of electric vehicles consume about 15kWh of energy for a journey of 100km (energuide.be, 2022), thus after considering the abovementioned charging tariffs in the Maltese Islands, a charging fee of €2 was included in the choice task. Battery replacement cost of petrol and diesel vehicles was set €90 and €100 respectively, which are approximate prices that consider the different battery prices on Tony's VRT Parts & Services Ltd (2021). On the other hand, after considering that electric vehicles' battery price ranges between approximately €5,000 and €14,500 (GreenCars, 2022), it was decided to refer to the lowest value of the range to determine if €5,000 to replace an electric vehicle battery represents a barrier in the adoption of electric vehicles.

Hypothetical scenario 2

The second hypothetical situation is intended to explain the effectiveness of financial incentives in promoting electric vehicle adoption, considering also that electric vehicles have the cheapest charging cost per 100km but the most expensive battery replacement cost. Therefore, in this scenario petrol, diesel and electric vehicle purchase prices were presented within the same range. The electric vehicle price presented in the first hypothetical situation was reduced considerably by applying the government financial subsidy which at the time of the study amounted to a maximum of €12,000 if the consumer scrapped his/her 10 year old vehicle. The road licence cost of electric vehicles was increased to €90, which is slightly cheaper than the licence cost of petrol (€111) and diesel (€121) vehicles. On the other hand, electric vehicles were still presented with the cheapest fuel / charging cost and the highest battery replacement cost.

Hypothetical scenarios 3 and 4

Both hypothetical scenarios studied if financial disincentives such as an increase in the purchase price and road licence cost of ICE vehicles in hypothesis 3 or an increase in the fuel cost in hypothesis 4 discourages the purchases of internal combustion engine vehicles versus electric vehicles. The price of ICE vehicles in hypothetical scenario 3 was increased to reflect the original price of the cheapest electric vehicle without the inclusion of financial subsidies. Road licence fees of petrol and diesel vehicles were increased to €550 and €560 to reflect the minimum current licence cost of the most polluting (more than 250g/km of CO_2) ICE vehicles in the Maltese Islands. Similar to scenario 1 and 2 electric vehicle charging cost per 100km is less than the petrol and diesel fuel cost per 100km while the electric vehicle battery replacement cost is higher than that of ICE vehicles. In hypothetical scenario 4 the vehicles' purchase price and road licence were in the same range, the electric vehicle battery cost was highest but when compared to scenario 1, the ICE vehicle fuel cost was doubled to be in line with those countries that charge the highest ICE vehicle fuel costs, namely Norway, Netherlands and Germany which are among the major electric vehicle adopters (autotraveler, 2022). The electric vehicle charging cost was also doubled to reflect any rise in the cost of electricity, yet it was still considered as the cheapest option.

Hypothetical scenario 5

High battery replacement cost may discourage individuals to purchase an electric vehicle, therefore, hypothetical situation 5 targets this aspect. All three vehicle types presented in the choice task have a relatively similar purchase price, road licence cost and fuel / charging cost, but the electric vehicle battery cost was reduced to €125. Thus, the exercise seeks to identify if battery replacement cost is an effective barrier during decision making.

Hypothetical scenario 6

The sixth hypothetical scenario presents a similar picture to that of hypothetical situation 5, where the road licence fee, fuel / charging cost and battery replacement cost among petrol, diesel and electric vehicles are within the same range. However, in this scenario, similar to scenario 1, the €12,000 government subsidy on the purchase of electric vehicles was not included as part of the electric vehicle purchase price. Moreover, unlike scenario 1 the road licence, fuel/charging and battery cost in scenario 6 were within the same range. Therefore, hypothetical scenario 6 is intended to identify whether consumers are still discouraged by an electric vehicle's high purchase price if all other attributes are within the same range.

Stated choice experiments 7, 8 and 9 similar to the first six choice experiments evaluate the influence of economic attributes: purchase price, subsidies and battery degradation on consumers' decision when considering electric vehicle adoption. However, unlike the first six choice experiments, choice experiments 7, 8 and 9 consider also the impact of non-economic attributes: charging / refuelling time and environmental concern on potential consumers. Therefore, choice experiments 7, 8 and 9 intend to evaluate if economic attributes are prevalent in decision making over non-economic attributes, consequently supporting the findings of the first six choice experiments when answering the first two research questions.

Hypothetical scenario 7

The seventh hypothetical scenario consists of five alternative situations and purchase price as the only attribute to seek consumer preference between the purchase of subsidised BEVs and unsubsidised PHEVs or HEVs. The fiscal incentive rates included in the choice experiment were the same incentives issued by the Maltese government at the time of the study which varied depending on whether the consumer opted or otherwise to scrap his/her old ICE vehicle. Although at the time of the research, subsidies on PHEVs were not issued anymore, the author still included an alternative where PHEVs are subsidised at the same rate as BEVs to understand whether consumers prefer PHEVs over BEVs or otherwise. This experiment apart from outlining the preferred choice among consumers accounted for decision making associated with old ICE vehicles. Thus, this choice task indicated whether electric vehicles are considered as a replacement to old ICE vehicles or just additional vehicles on the road.

Hypothetical scenario 8

Charging time results to be one of the barriers that slows electric vehicle adoption, thus the eighth choice experiment focused on the three charging alternatives present in the Maltese Islands; slow AC home charge, medium AC charging pillars and fast DC charging pillars. The slow home charging tariff presented in the exercise was obtained from Enemalta (2021) while tariffs of medium and fast charging pillars were obtained from Government of Malta (2021b). The exercise aimed in giving a picture of the preferred charging alternative in relation to battery degradation. Although the in-built battery of a new electric vehicle is covered by an 8-year manufacturer guarantee (Gilmore, 2022), battery replacement cost is still high. Thus, the choice experiment established whether consumers prefer to opt for longer charging time options to preserve the battery's life or whether consumers prefer to save charging time at the expense of a higher battery degradation rate, which consequently necessitates replacement in a shorter timeframe.

Hypothetical scenario 9

The level of environmental concern among Maltese consumers was evaluated in the ninth choice experiment which consisted of four attributes (vehicle price, driving range, charging / refuelling time and carbon dioxide emissions) and four alternatives, BEV, PHEV, HEV and ICE vehicles. The BEV, PHEV and HEV purchase prices utilised were the same as those in the previous experiments which excluded any government subsidies since the aim was to assess whether economic concerns are higher than environmental concerns or vice versa. The driving range was set 300km for all vehicle alternatives to ascertain that the respondents' choice is not conditioned by the attribute. Refuelling /charging time reflect the situations presented in previous experiments. Percentages were utilised for easy comparisons related to carbon dioxide emissions, where emissions from ICE vehicles was set as 100% while that of BEV as 0%. Since PHEVs operate on both an in-built battery and an internal combustion engine, carbon dioxide emissions were set as 50%. On the other hand, emissions from an HEV were assumed to be 75%, because such vehicles operate mainly on an internal combustion engine.

3.6. Analytical Methodology

The primary data collected from the stated preference survey was inputted and processed utilising IBM SPSS Statistics 28 software. IBM SPSS Statistics 28 software facilitated the process of performing multivariate regression analysis utilising the Multinomial logit model (MNL).

3.6.1. Regression analysis

Regression analysis aims at studying a linear or a non-linear relationship between two or more variables that have a cause-effect relationship on each other to establish predictions (Uyanık and Güler, 2013). Univariate analysis uses a single independent variable, and a relationship is established between an independent and a dependent variable utilising a set of statistical techniques. Univariant analysis is applied when studying central tendency, dispersion, and frequency distribution. Bivariate analysis examines the correlation between two variables and establishes if the correlation is significant or occurred by chance. To examine more than two variables a multivariate analysis is necessary (Bhattacherjee, 2012).

3.6.2. Regression models in literature

Literature associated with electric mobility utilises various regression models to identify patterns related to the attributes that influence consumers' willingness to pay (WTP) for electric vehicles. The commonly utilised models are illustrated in Table 3.3. Out of all the regression models listed in Table 3.3, the most utilised models to evaluate electric vehicle attributes are the Multinomial logit (MNL) model and the Mixed Logit (ML) model (Bera and Maitra, 2021). The Multinomial logit model is a discrete choice model which relates multiple discrete independent variables to a categorical dependent variable. It has been utilised to study different types of individual behaviour, including behaviour associated with the purchase of electric vehicles (Junquera et al., 2016; Moreno et al., 2016; Qian and Soopramanien, 2011). Indeed, Zhuge and Shao (2019) used Multinomial logit models to study the relationship between socio-demographic attributes and different influential factors.

Besides from discrete choice models, structural equation modelling (Degirmenci and Breitner, 2017) and the chi-squared test were also utilised in certain studies to analyse the purchase of electric vehicles. The chi-squared test evaluates the statistical association between variables, with Egbue and Long (2012) utilising the test to study the differences in attitudes and perceptions that influence the purchase of electric vehicles.

After considering the modelling solutions applied in various literature (see Table 3.3), it was decided to utilise the Multinomial logit (MNL) model to model the data collected from the first six stated choice experiments in the questionnaire survey (see Appendix A). The mentioned choice experiments provide six hypothetical scenarios which were intended to give an understanding of the degree of influence different economic attributes have on decision-making regarding the choice of purchasing either an electric or an ICE vehicle. In the regression model, the economic attributes: purchase price, road licence cost, fuel/charging cost and battery replacement cost were considered as discrete independent variables (predictors), while the vehicle choice among the following vehicle alternatives: petrol, diesel and electric as the dependant variable (see table 3.7). As stated earlier, hypothetical scenarios 7, 8 and 9 were not designed to be processed utilising the Multinomial logit (MNL) model, but as an addition to support the findings of the first six choice experiments and measure the effectivity of economic attributes in influencing consumers' decisions when deciding about the adoption of electric vehicles.

Multinomial logit (MNL) model	
Independent variables	***Dependent variable***
Purchase price	Vehicle type - Petrol - Diesel - Electric
Road licence cost	
Fuel / charging cost	
Battery replacement cost	

Table 3.7: The independent and dependent variables as studied in the Multinomial logit model. Source: Compiled by author

3.7. Descriptive statistics of the survey sample population

Age and Gender

A total of 391 participants of 18 years of age and over, who have a driving licence or have the potential to obtain a driving licence completed the questionnaire survey. Table 3.8 shows that respondents between 18 – 48 years compose the largest percentage of the sample population studied (62.92%). This confirms the tendency mentioned by Junquera et al. (2016) and Zhuge and Shao (2019) that younger age groups tend to participate more in online surveys when compared to older age groups. In fact, individuals that are 49 years of age and over composed 37.08% of the sample population under study (see Table 3.8).

The percentage of male respondents resulted to be higher in all age groups, except in the 39 - 48 years age group where female respondents exceeded male respondents by 1.27%. The gender difference throughout all age groups compliments the findings of other researchers in the field who identify males as the gender group which is more keen to adopt electric vehicles (Hjorthol, 2013; Bjerkan et al., 2016; Plötz et al., 2014, Mohamed et al., 2016; Kim et al., 2014; Carley et al., 2013; Egbue and Long, 2012) and also the gender who is interested mostly in purchasing such vehicles (Hidrue et al., 2011; Bjerkan et al., 2016; Plötz et al., 2014; Mohamed et al., 2016; Kim et al., 2014; Jia and Chen, 2021; Vassileva and Campillo, 2017; Egbue and Long, 2012).

Employment, Martial status and level of education

The survey sample population is composed mainly from employed individuals (70.08%) and the majority of the participants are married (54.22%) while 39.13% are single (see Table 3.8). A high percentage of the participants possess a tertiary level of education, where 39.90% and 27.37% of the participants have respectively an undergraduate qualification and a postgraduate qualification (see Table 3.8).

Regular residence location and type

The majority of the participants reside in the Southern Harbour district (27.37%) and the South-Eastern district (25.83%) while only 5.37% reside in the Gozo and Comino district (see Table 3.8). The low percentage of Gozitan participants may be influenced by the fact that a number of Gozitans have their regular residence in Malta in order to be close to their place of work or academic institution in the case of students. Furthermore, since data for this study was collected utilising simple random sampling, a balanced participation among the six districts was not guaranteed, considering also that the total population of Gozo and Comino is much lower than that of Malta (see section 1.3.1).

		Percentage	
		Males	**Females**
Age	18 – 28	11.00%	8.70%
	29 – 38	12.02%	8.95%
	39 – 48	10.49%	11.76%
	49 – 58	9.72%	7.16%
	59 – 65	4.35%	3.32%
	65 +	7.67%	4.86%
Marital Status	Single	39.13%	
	Married	54.22%	
	Widowed	2.56%	
	Separated	3.83%	
	Divorced	0.26%	
Education level	Secondary education	8.18%	
	Sixth form education	24.55%	
	Undergraduate qualification (certificate, diploma, Bachelor's degree)	39.90%	
	Postgraduate qualification certificate (certificate, diploma, Master degree, Ph.D)	27.37%	
Employment Status	Employed	70.08%	
	Unemployed	3.32%	
	Retired	13.30%	
	Student and also a part-time employee	4.60%	
	Student performing no part-time jobs	7.42%	
	Self-Employed	1.28%	
Location of regular residence by district	Southern Harbour District	27.37%	
	Northern Harbour District	13.81%	
	South-Eastern District	25.83%	
	Western District	12.28%	
	Northern District	15.35%	
	Gozo and Comino District	5.37%	

Table 3.8: Descriptive statistics of the socio-demographic profile of the sample population.

As indicated by Figure 3.2, the majority of the survey participants in all districts live in a house that has a garage with access to electricity, followed by a maisonette / apartment with garage ownership and access to electricity. However, the trend obtained from the survey may not fully reflect current Maltese reality, since according to The Malta Independent (2018), 53.8% of the Maltese population in 2018 lived in apartments. According to Table 3.9, 72.12% of the households own two vehicles or more, indicating that nearly three quarters of the sample population resides in a multi-car household. This is evident in Figure 3.3, where the highest percentage of vehicle ownership is associated with a house that has a garage with access to electricity, followed by a maisonette / apartment with garage ownership and access to electricity. 57.2% of the participants who do not own a vehicle live either in a house without a garage (42.9%) or in a maisonette / apartment without a garage (14.3%). Furthermore, 14.3% of those participants who do not own a vehicle live in a house with a garage that has no access to electricity (see Figure 3.3).

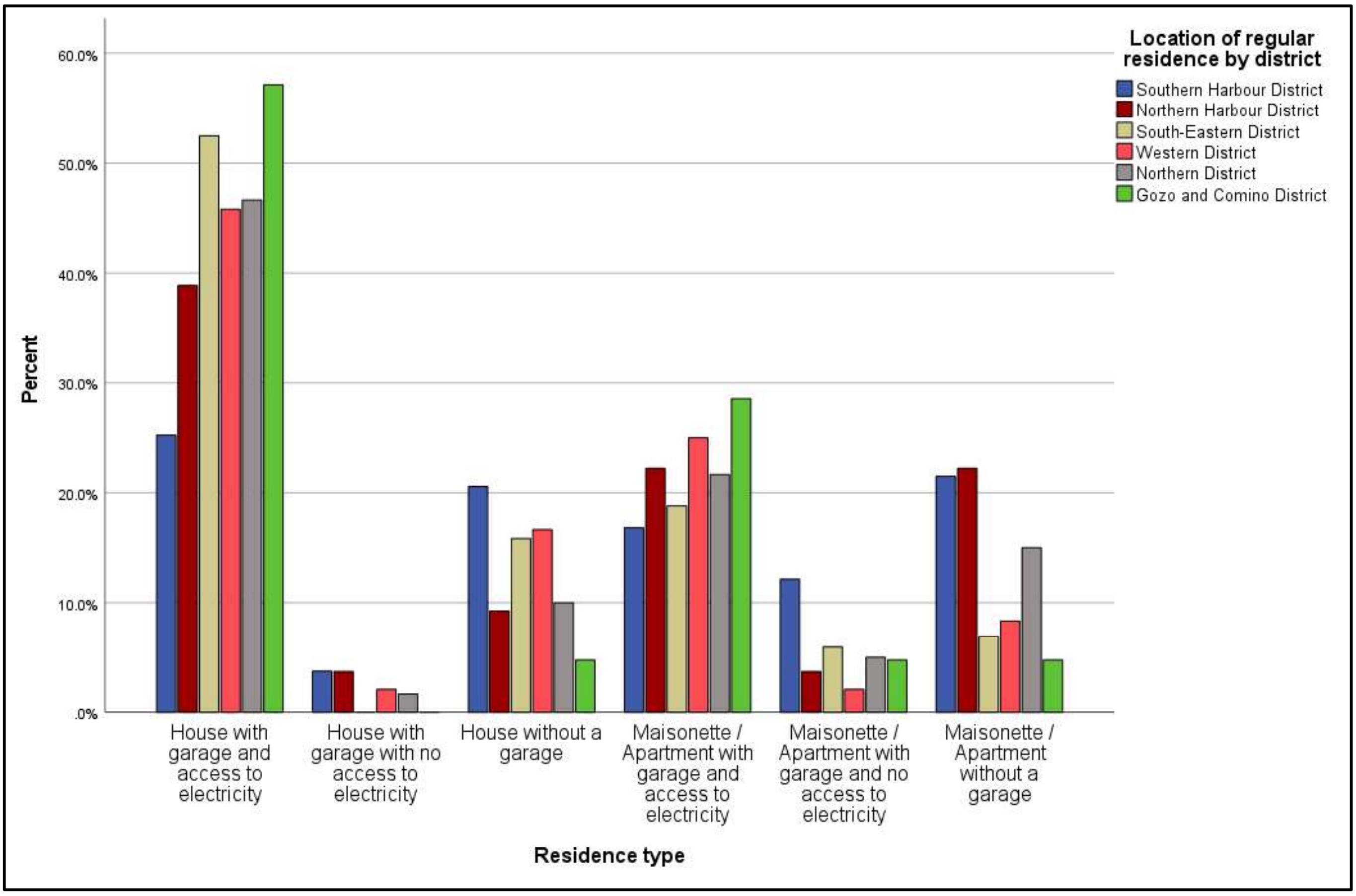

Figure 3.2: The respondents' regular residence by district and type of residence.

Total number of vehicles owned by the household			
		Frequency	Percentage
Valid	None	7	1.79
	One	102	26.09
	Two	156	39.90
	Three	79	20.20
	Four	41	10.49
	More than four	6	1.53
	Total	391	100.00

Table 3.9: Total number of vehicles owned by the household.

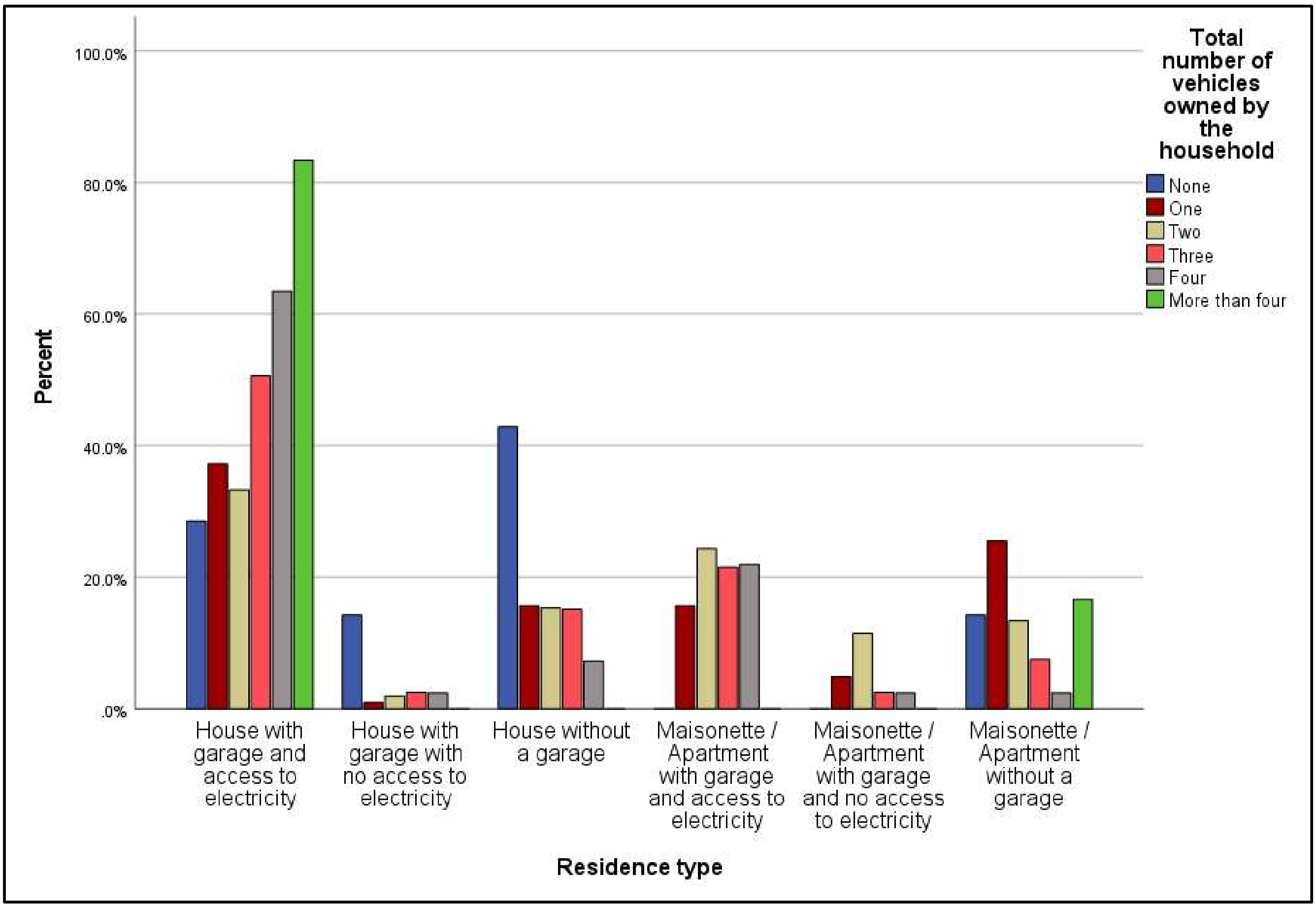

Figure 3.3: Type of residence and number of vehicles owned by the household.

Electric vehicle ownership

The study shows that 83.13% of the participants (325 individuals), do not own an electric vehicle while only 16.88% of the participants (66 individuals) own an HEV, PHEV or a BEV. When considering electric vehicle ownership in households, 78.52% of the households where participants live, do not own an electric vehicle and 19.95% of the households that own electric vehicles, own only one electric vehicle (see Table 3.10). This reflects the figures published in NSO (2023a) where electric vehicle adoption is still low in the Maltese Islands. According to Figure 3.4, the most popular type of electric vehicle in those households that own at least one electric vehicle is the BEV (45.5%), followed by the PHEV (25.8%) and the HEV (21.2%). This percentage distribution might have been influenced by the consumers' possibility of benefitting from the government grant which is currently granted to those individuals who purchase a BEV. Out of the households who own more than one electric vehicle, 3% own both an HEV and a PHEV, 1.5% own both an HEV and a BEV and 3% own both a PHEV and a BEV.

Electric vehicle ownership (HEV, PHEV, BEV)	Yes	16.88%
	No	83.13%
Number of electric vehicles (HEV, PHEV, BEV) owned by the household	None	78.52%
	One	19.95%
	Two	1.27%
	Three	0.26%
	Four and more	0.00%

Table 3.10: Electric vehicle ownership among the sample population.

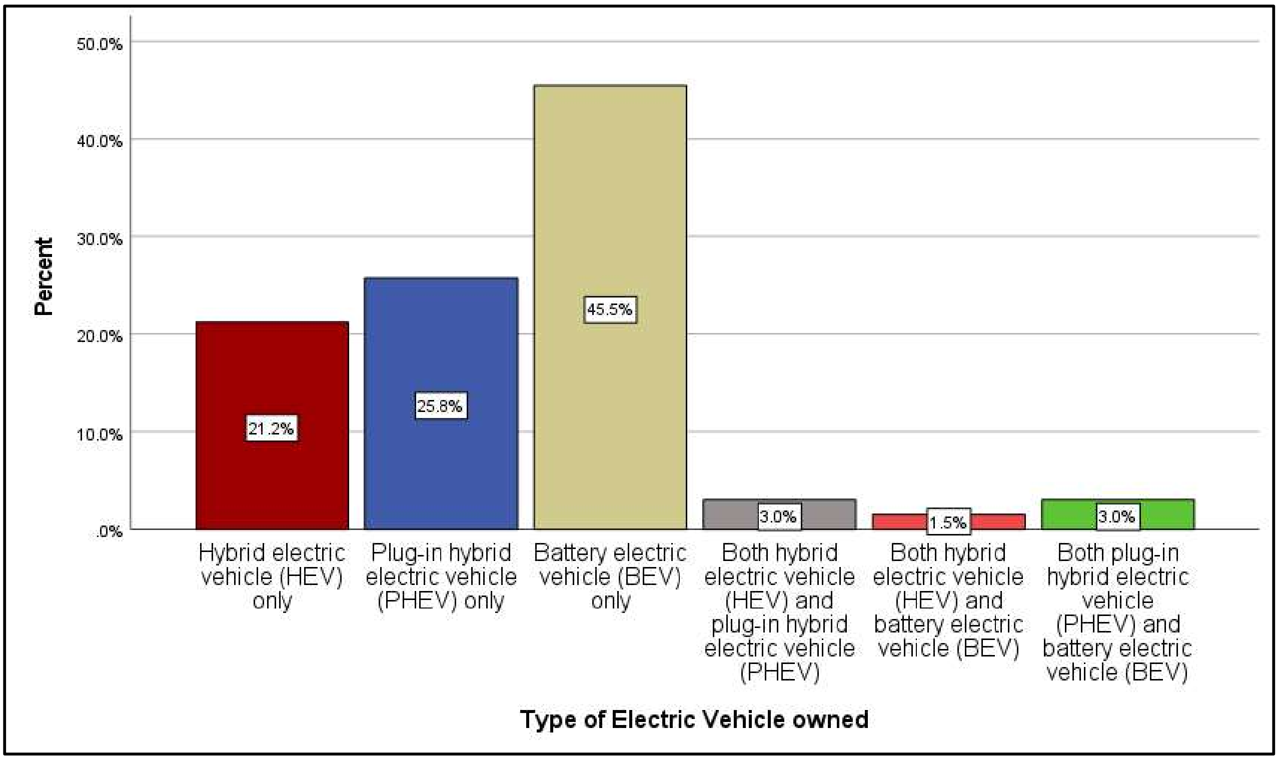

Figure 3.4: Type/s of electric vehicles owned by the household.

Three hundred and twenty-five individuals out of 391 participants do not own an electric vehicle of any type and as seen in Tables 3.11, 3.12 and 3.13, the vast majority of these individuals never experienced an electric vehicle of any type. In fact, 94.6%, 94.77% and 94.46% of the respondents never experienced an HEV, PHEV and BEV, respectively. As it is evident in Figure 3.5, the lack of electric vehicle driving experience among the public seems also to influence the opinion of those individuals who do not own a vehicle and who may be prospective future drivers. 39.2% of the participants who do not own a vehicle opt for an ICE vehicle and 33.8% opt for an HEV as their future vehicle. The least popular vehicle among possible future drivers is the BEV (5.4%), which is also the most expensive type of vehicle on the market.

HEV driving experience		
	Frequency	Percentage
Never	307	94.46
Once	10	3.08
More than once	8	2.46
Total	325	100.00

Table 3.7: HEV driving experience of participants that do not own an EV.

PHEV driving experience		
	Frequency	Percentage
Never	308	94.77
Once	7	2.15
More than once	10	3.08
Total	325	100.00

Table 3.8: PHEV driving experience of participants that do not own an EV.

BEV driving experience		
	Frequency	Percentage
Never	307	94.46
Once	12	3.69
More than once	6	1.85
Total	325	100.00

Table 3.9: BEV driving experience of participants that do not own an EV.

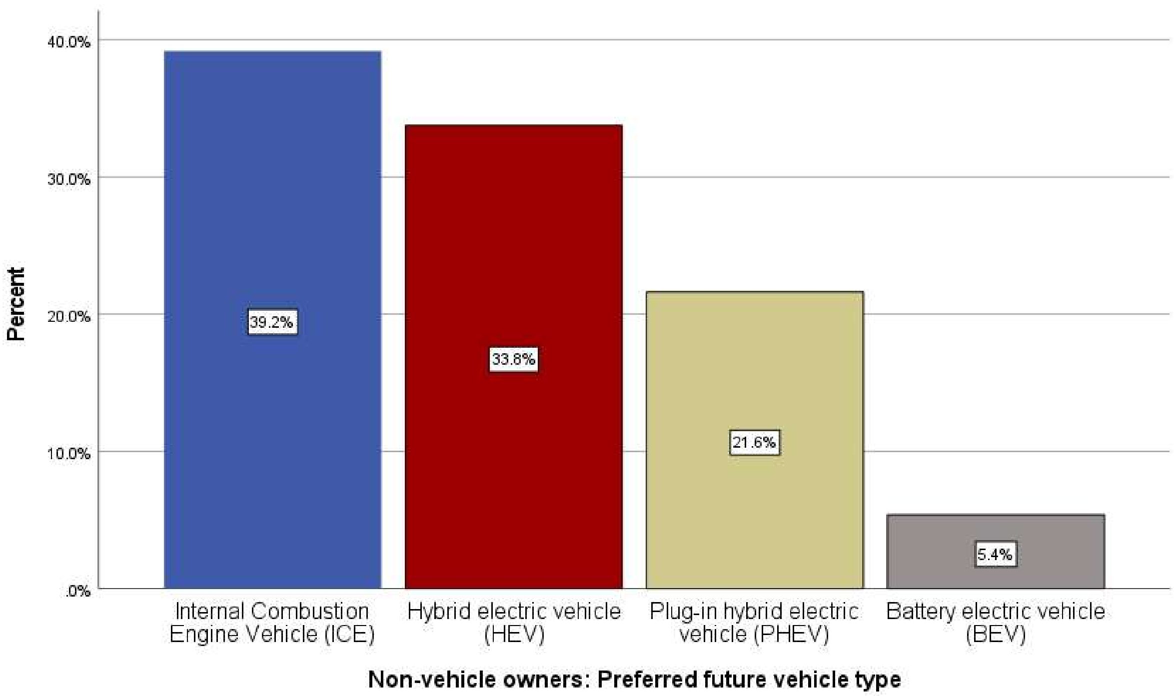

Figure 3.5: Prospective future vehicle owners' preferred vehicle type.

3.8. Conclusion

This chapter provided an overview of the methodology applied in the study in order to gather and process the collected data. Reference was done to the field survey approach, questionnaire design as well as to the data analysis techniques all of which were explained and justified. Finally, a description of the sample used in the study was given. The results obtained following the data collection exercise were presented and correlated in chapter 4 utilising charts, tables and results of statistical modelling.

CHAPTER 4: RESULTS AND ANALYSIS

4.1. Introduction

This chapter describes the outcome of the questionnaire survey analysis and results and is subdivided into three sections. First, crosstabulation has been applied to study the association between electric vehicle ownership and each of the following socio-demographic variables: age, gender, marital status, level of education, employment status, location and type of the regular residence, the budget spent when buying a vehicle and the number of vehicles in the household. Chi-Square tests were also utilised to test the significance of each association. The second section analyses the Likert Scale results which are intended to study the respondents' knowledge, attitude and perception towards electric vehicle adoption. Finally, the Multinomial logit model was utilised to establish whether the price and running costs are determinant barriers in the uptake of electric vehicles. Furthermore, the model also establishes whether fiscal incentives are an effective tool in the promotion of electric vehicles among consumers.

4.2. Evaluating the relationship between different socio-demographic variables and electric vehicle adoption

This section studies the association between the different demographic variables described in section 3.7 and electric vehicle adoption using crosstabulation. Crosstabulation is a statistical technique that correlates two variables, allowing the identification of those associations that are mostly influential in the field under study. The results obtained from crosstabulation exercises will then be evaluated utilising the Pearson Chi-Square test which is a useful test to establish if the results obtained are statistically significant or otherwise. Each Chi-Square test provides a p-value, which has to be compared to the 0.05 level of significance. The correlation between the variables studied using crosstabulation is considered significant if the p-value obtained is smaller than 0.05 level of significance (Pandis, 2016).

The association between age and electric vehicle ownership

Similar to Table 3.7, Figure 4.1 shows clearly that aside from the 59 – 65 year age group the participants from all age groups, owning an electric vehicle is lower when compared to those individuals who do not own such vehicles. On the other hand, in the 59 – 65 year age group, the percentage of electric vehicle owners is balanced with the percentage of non-electric vehicle owners. According to Figure 4.1, the highest percentage of electric vehicle owners are individuals that are 59 years of age and older. Therefore, such findings conform with the study performed by Esteves et al. (2021) and contrast with Jia and Chen (2021); Hidrue et al. (2011); Vassileva and Campillo (2017; Sovacool et al. (2018). Nonetheless, it is also important to consider that the respondents composing the 59 – 65 year age group and the 65+ year age group are lesser in number when compared to younger age groups (see Table 3.7).

Since the Chi-Square test resulted in a p-value of 0.001 which is less than the 0.05 level of significance, indicates that the association between age and electric vehicle ownership is significant. This means that age is an influential variable in the adoption of electric vehicles (see Appendix B, Tables B1 and B2).

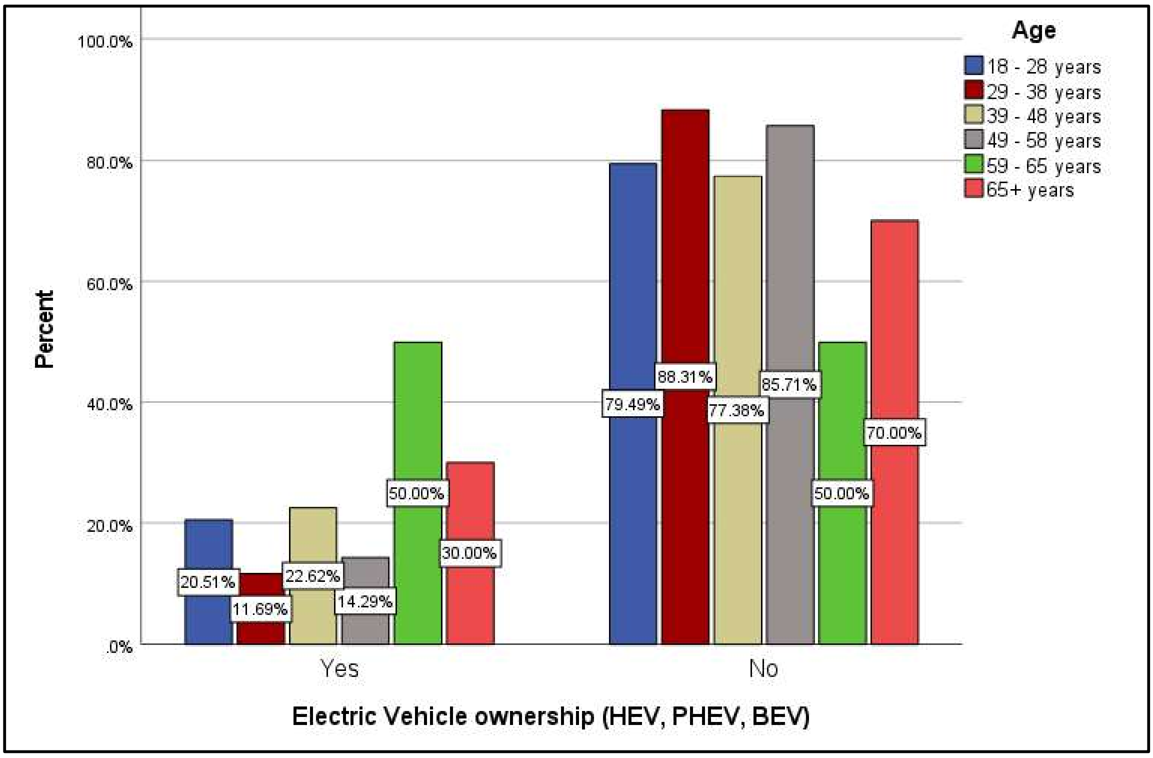

Figure 4.1: A graphical representation of the crosstabulation between age and electric vehicle ownership.

The association between gender and electric vehicle ownership

Figure 4.2 indicates that males adopt mostly electric vehicles, 24.47% males and 15.5% females. However, the association between gender and electric vehicle ownership cannot be considered as significant because the p-value obtained from the Chi-Square test is 0.053 which is marginally larger than the 0.05 level of significance (see Appendix B, Tables B3 and B4).

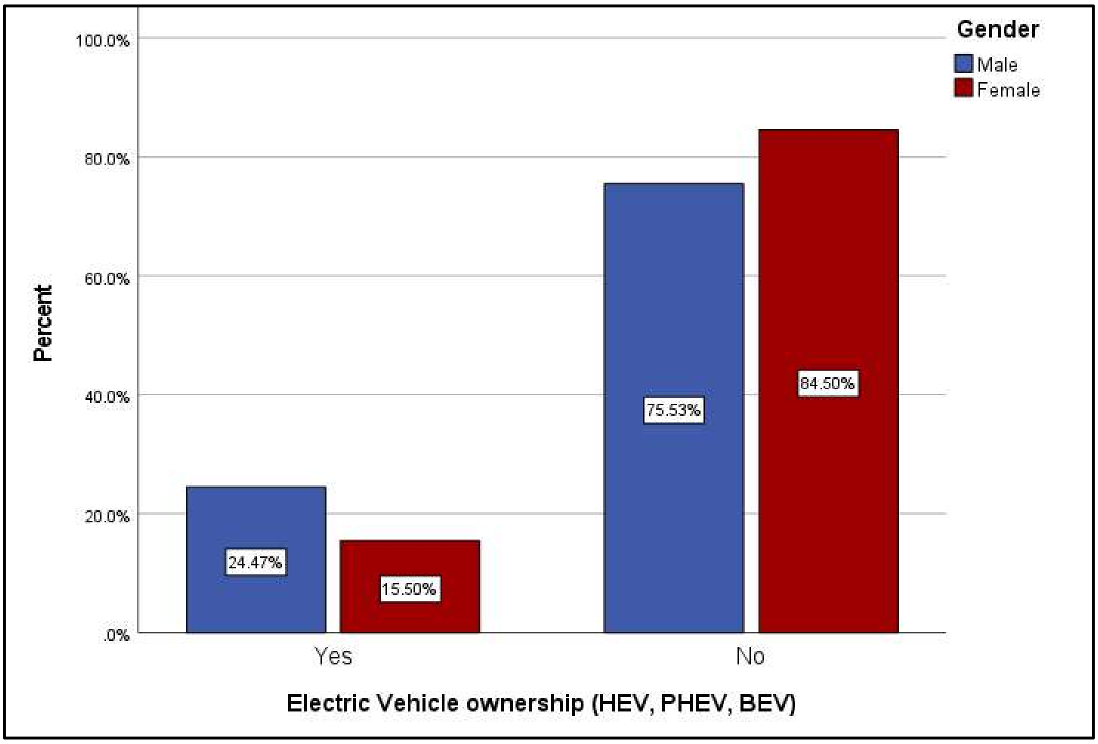

Figure 4.2: A graphical representation of the crosstabulation between gender and electric vehicle ownership.

The association between marital status and electric vehicle ownership

Although Figure 4.3 indicates that 100% of the individuals who are divorced have an electric vehicle, the percentage obtained cannot be considered as tenable because according to Appendix B Table B5, only one individual from the sample population declared the "divorced" status. In fact, Table 3.7 also shows that 54.22% and 39.13% of the respondents are respectively married and single. Therefore, if the divorced status is excluded, electric vehicle ownership results to be most popular among those survey participants who are married (see Figure 4.3) since they can benefit from a dual income.

The association between marital status and electric vehicle ownership is also significant, because the p-value of 0.024 obtained from the Chi-Square test is smaller than the 0.05 level of significance (see Appendix B, Tables B5 and B6).

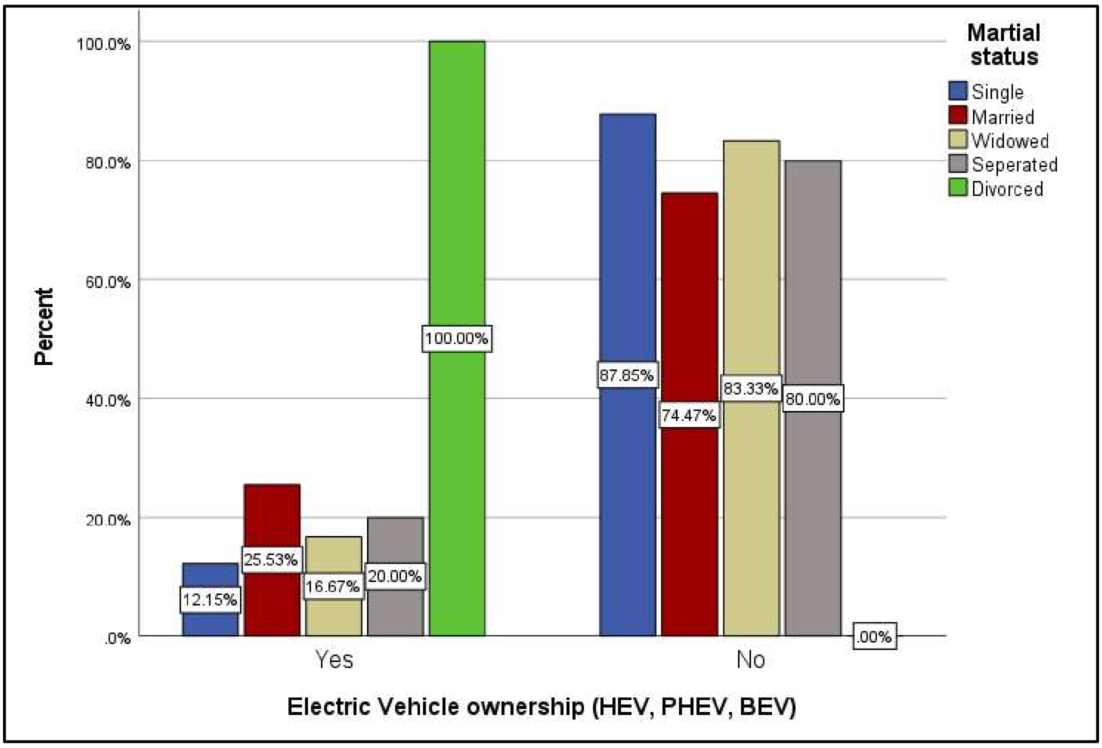

Figure 4.3: A graphical representation of the crosstabulation between marital status and electric vehicle ownership.

The association between level of education and electric vehicle ownership

Numerous studies (Vassileva and Campillo, 2017; McKinsey & Company, 2014; Hjorthol, 2013; Bjerkan et al., 2016; Plötz et al., 2014; Simsekoglu, 2018; Parsons et al., 2014; Kim et al., 2014; Jia and Chen, 2021) state that electric vehicle adopters are often individuals with a certain level of education. According to Figure 4.4, 24.51% of the respondents who have an electric vehicle have a postgraduate qualification, 20% have an undergraduate qualification, 21.05% sixth form education while only 8.70% terminated their studies at secondary school. Nonetheless, the association between level of education and electric vehicle ownership is not considered significant because the Chi-Square test result of 0.399 is by far larger than the 0.05 level of significance (see Appendix B, Tables B7 and B8).

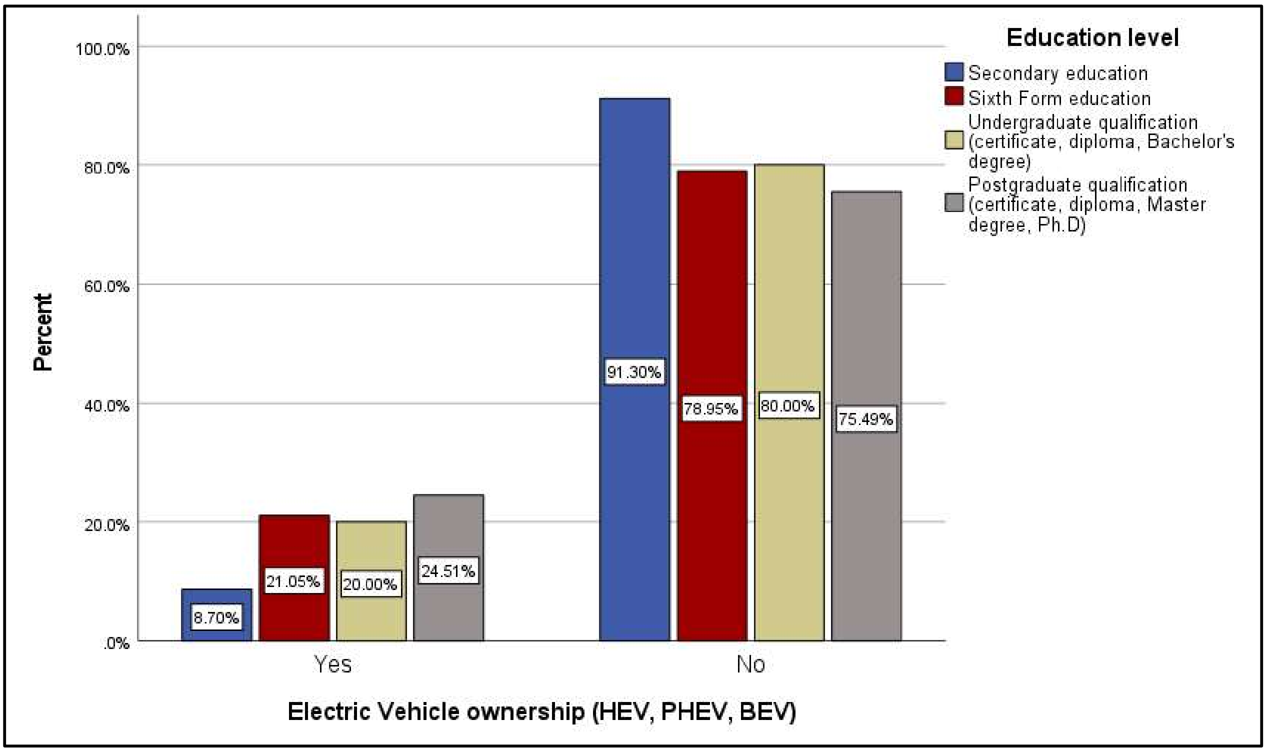

Figure 4.4: A graphical representation of the crosstabulation between level of education and electric vehicle ownership.

The association between employment status and electric vehicle ownership

As seen in Figure 4.5, electric vehicle ownership results to be highest among self-employed and retired people, 40% and 35.48% respectively. This is followed by students who are part-time employees (25%) and students who do not have a part-time job (20%). As expected, only unemployed individuals (including housewives) do not own an electric vehicle, potentially due to economic constraints. The Chi-Square test result of 0.199 is larger than the 0.05 level of significance (see Appendix B, Tables B9 and B10), thus the association between employment status and electric vehicle ownership is not significant.

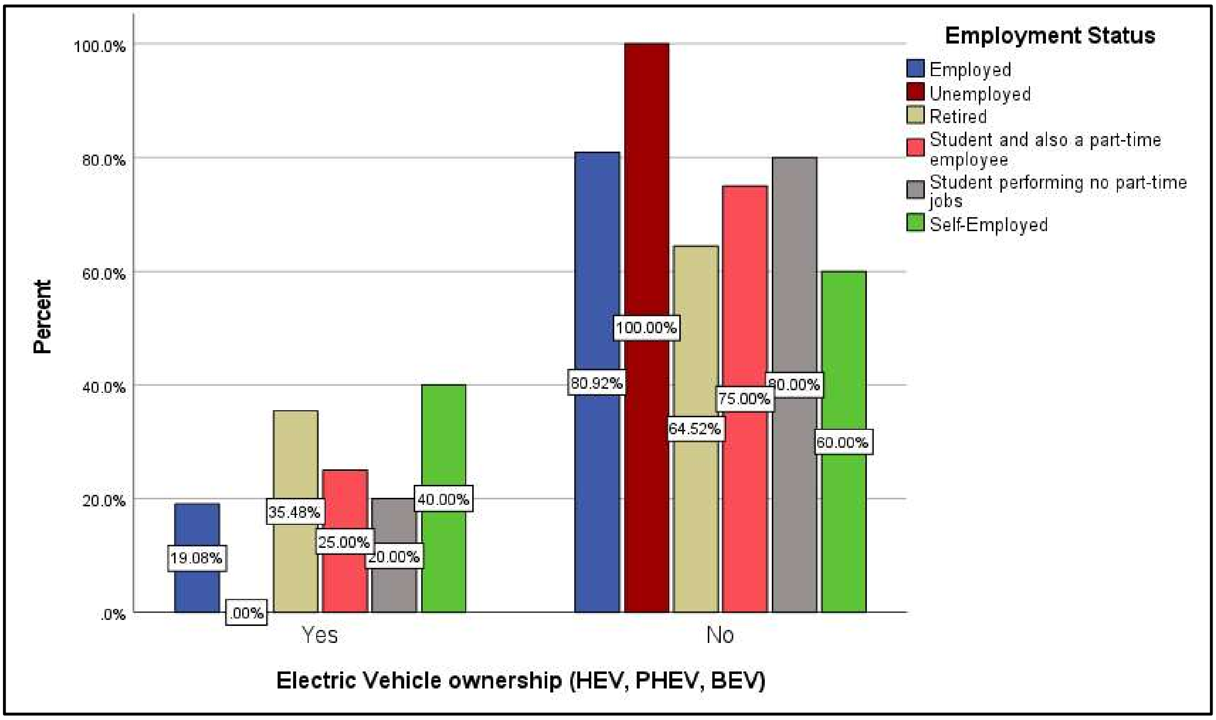

Figure 4.5: A graphical representation of the crosstabulation between employment status and electric vehicle ownership.

The association between the regular residence by district and electric vehicle ownership

The survey showed that the Western district (32.43%) and the Northern district (31.37%) are the most popular districts where electric vehicle owners reside. On the other hand, electric vehicle ownership is lowest in the Southern Harbour district (see Figure 4.6). This trend compliments with the data presented in Table 1.1 where according to NSO (2022d; 2023b), the Northern, Northern Harbour and Western districts are the districts with least old, licensed passenger vehicles in the Maltese Islands. On the other hand, the Southern Harbour is the district with the oldest licensed passenger vehicles. Furthermore, in the year 2019, the Southern Harbour was the district which experienced the highest increase in poverty levels, with a registered increase of 40.7% in the number of individuals who are at risk of poverty (NSO, 2022b). Therefore, consumers residing in the Southern district may be less keen to buy a new electric vehicle.

The association between the two variables is significant because the p-value 0.009 obtained from the Chi-Square test is smaller than the 0.05 level of significance (see Appendix B, Tables B11 and B12).

When considering the association between the regular residence by district and the number of electric vehicles owned by the household (see Figure 4.7), the Northern district had the highest percentage of respondents (5%) who own two or more electric vehicles. The Northern district was followed by the Northern Harbour district (3.70%) and the Western district (2.08%). None of the participants residing in the other districts own more than one electric vehicle. Similar trends can also be observed in NSO (2022b), where it has been reported that in 2020, the Northern harbour and the Northern districts are the most affluent districts with the highest disposable income per year.

The Chi-Square test p-value of 0.017 indicates that the association between the regular residence by district and the number of electric vehicles owned by the household is significant (see Appendix B, Tables B13 and B14).

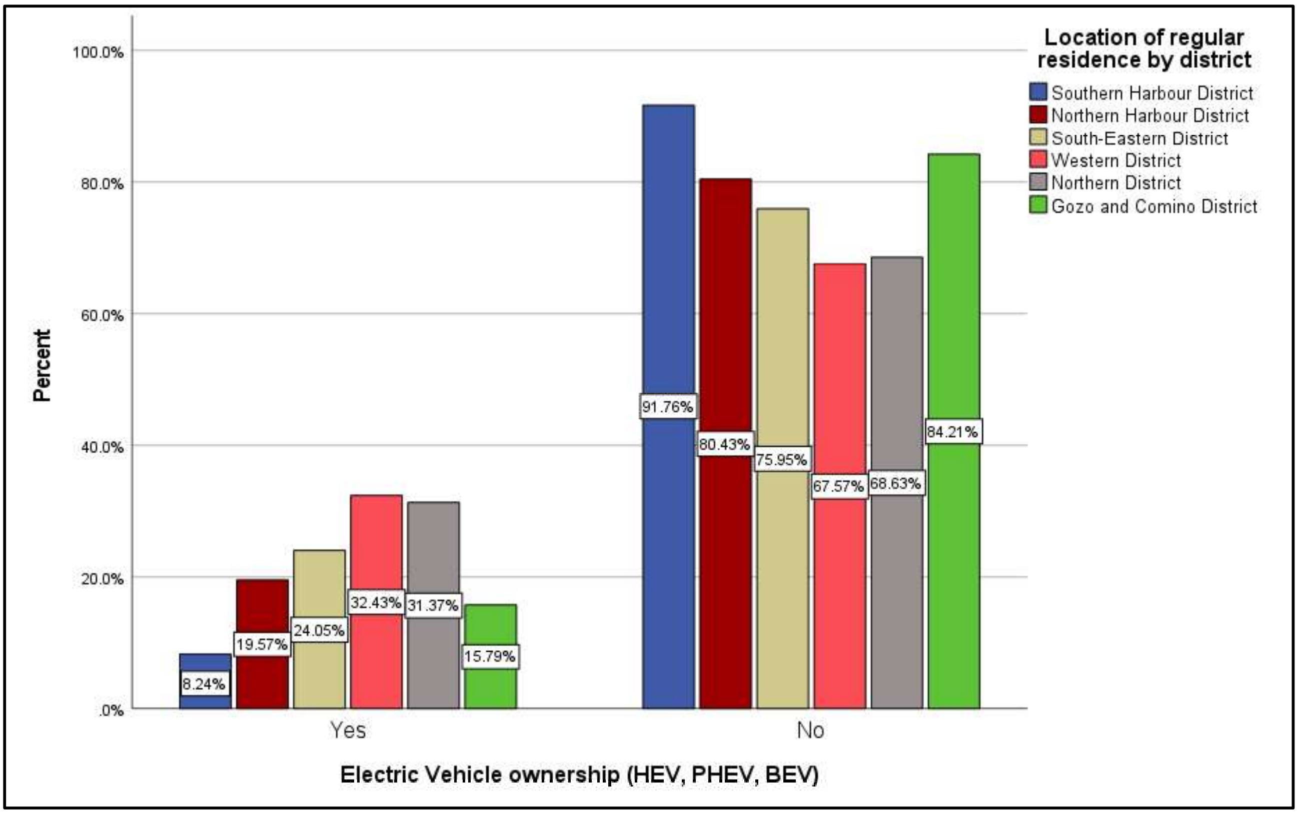

Figure 4.6: A graphical representation of the crosstabulation between the residence location by district and electric vehicle ownership.

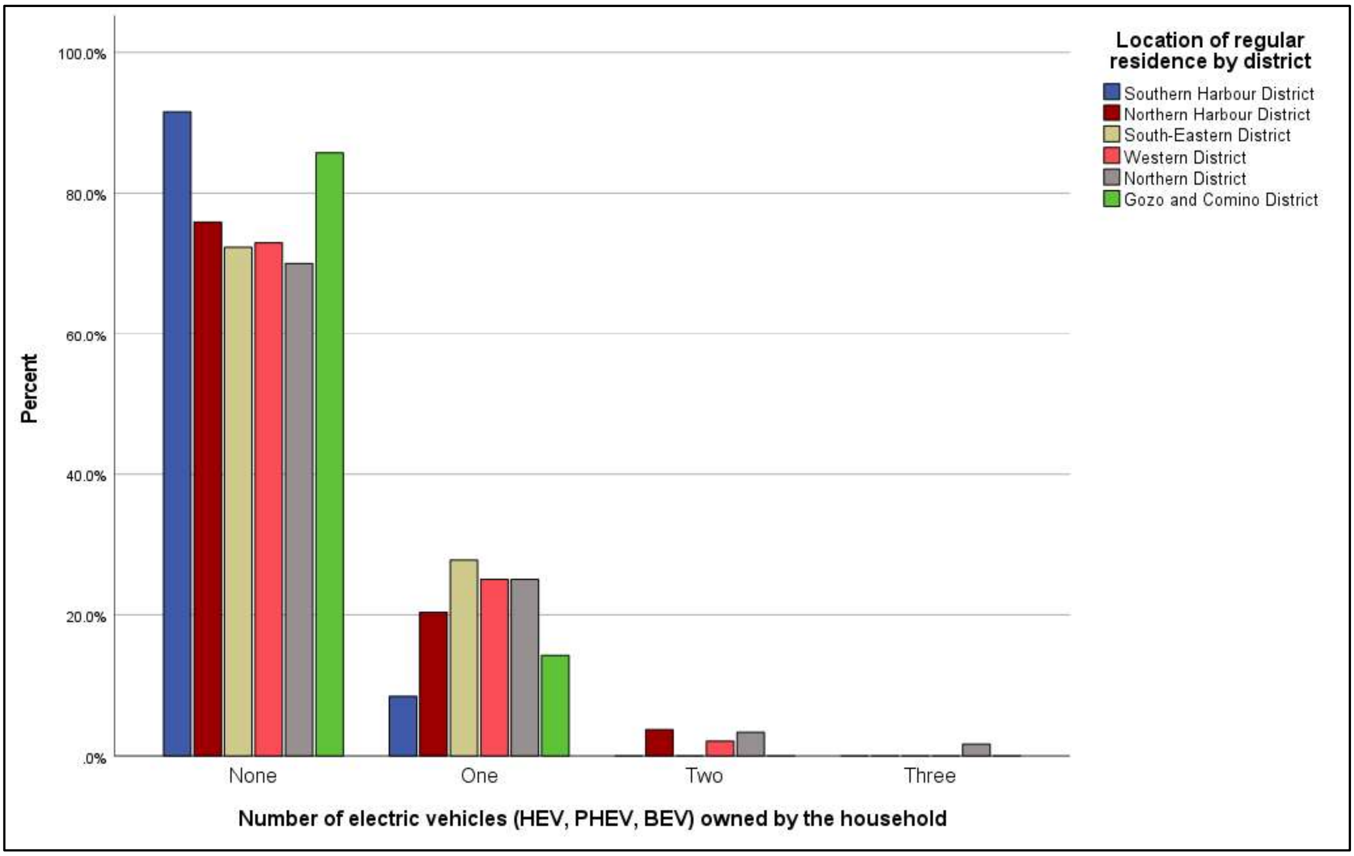

Figure 4.7: A graphical representation of the crosstabulation between the residence location by district and the number of electric vehicles owned by the household.

The association between the usual budget when buying a vehicle and electric vehicle ownership

Over 96% of the sample population confirm that price is a determinant variable when considering the purchase of electric vehicles. Most non-vehicle owners, a number of whom are students who are planning to purchase their first vehicle, have a vehicle purchase budget of less than €10,000 (77.03%). On the other hand, 44.79% of vehicle owners have a purchase budget between €10,001 and €20,000, 25.55% have a purchase budget of less than €10,000 while 21.77% have a purchase budget between €20,001 and €30,000. Only 7.88% of vehicle owners have a purchase budget of over €30,000 (see Figures 4.8 and 4.9).

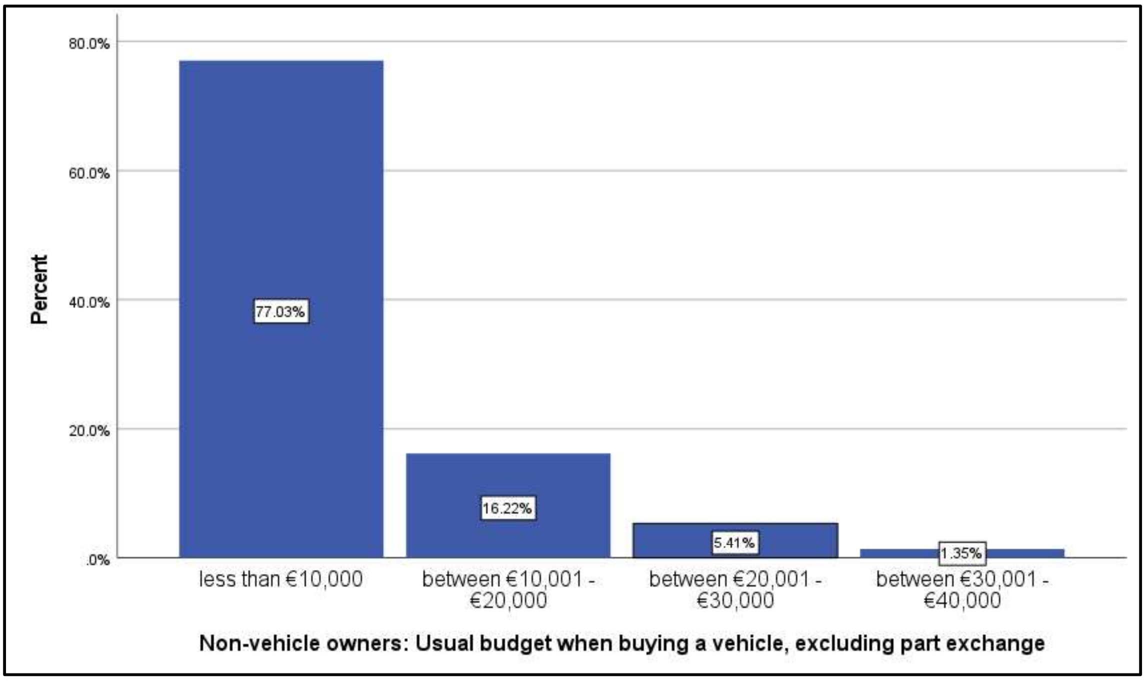

Figure 4.8: The vehicle purchase budget of non-vehicle owners.

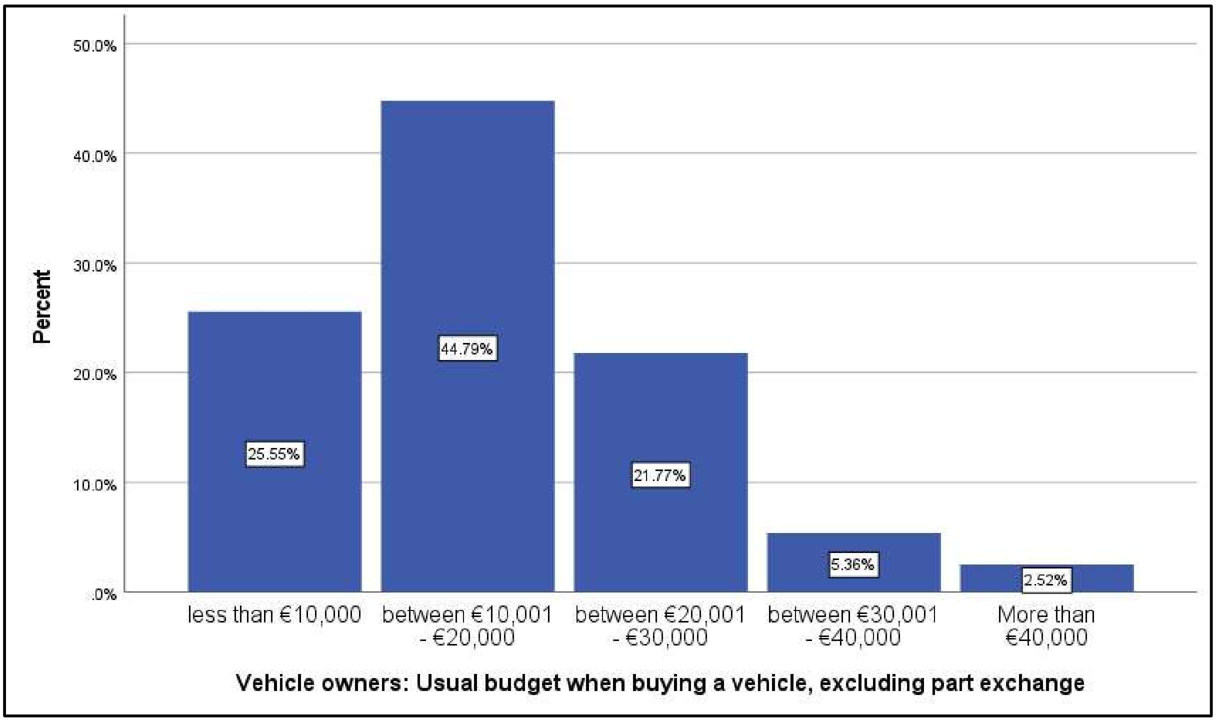

Figure 4.9: The usual vehicle purchase budget of vehicle owners.

When associating the usual vehicle purchase budget with electric vehicle ownership (see Figure 4.10), individuals who have a vehicle purchase budget of over €20,000 have a higher tendency to buy an electric vehicle. Furthermore, a high purchase budget also has an influence on the number of electric vehicles purchased by the household (see Figure 4.11). Therefore, similar to Sierzchula et al. (2014), Larson et al. (2015) and Junquera et al. (2016), the high purchase price of electric vehicles can be considered a barrier in the adoption of such vehicles by Maltese consumers. In fact, only 3.7% of the participants whose usual vehicle purchase budget is less than €10,000 own an electric vehicle.

Chi-Square tests testing the association between the usual budget when buying a vehicle and electric vehicle ownership (see Appendix B, Tables B15 and B16) and the usual budget when buying a vehicle and number of electric vehicles owned by the household (see Appendix B, Tables B17 and B18) resulted to be both significant. In both cases the p-value is less than 0.001 level of significance, thus smaller than the 0.05 level of significance.

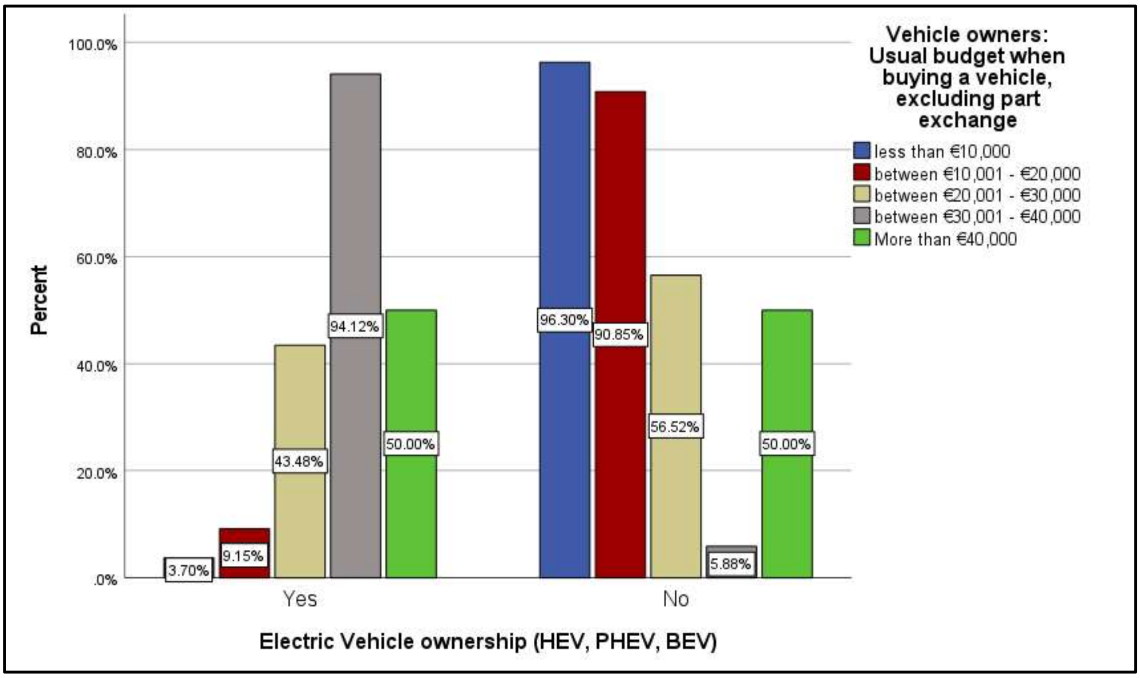

Figure 4.10: A graphical representation of the crosstabulation between the usual budget when buying a vehicle and electric vehicle ownership.

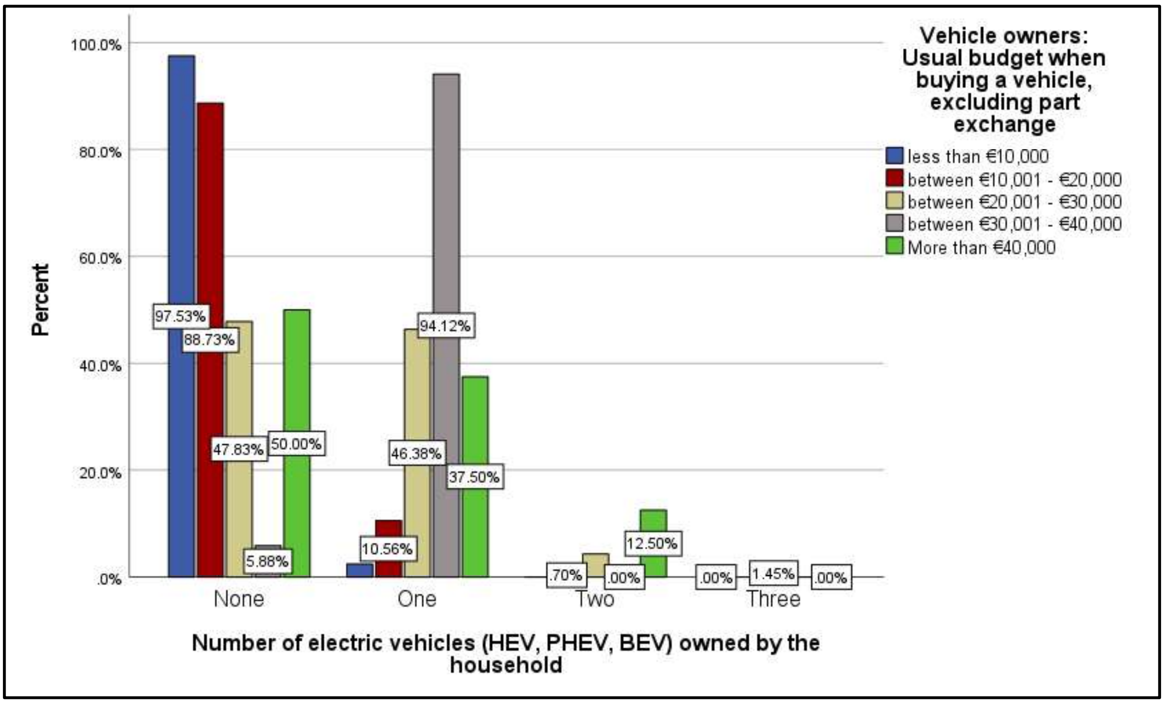

Figure 4.11: A graphical representation of the crosstabulation between the usual budget when buying a vehicle and number of electric vehicles owned by the household.

The association between the residence type and electric vehicle ownership

Figure 4.12 shows that electric vehicle ownership is higher among participants who live in a house with a garage and have access to electricity (27.62%) and among those who live in a maisonette / apartment with a garage and have access to electricity (27.14%). On the other hand, electric vehicle ownership is lowest among participants who live in a maisonette/apartment with a garage but have no access to electricity (5%) and those that live in a maisonette / apartment without a garage (8.89%). The association between the residence type and electric vehicle ownership resulted to be significant because the Chi-Square test p-value of 0.008 is smaller than the 0.05 level of significance (see Appendix B, Tables B19 and B20).

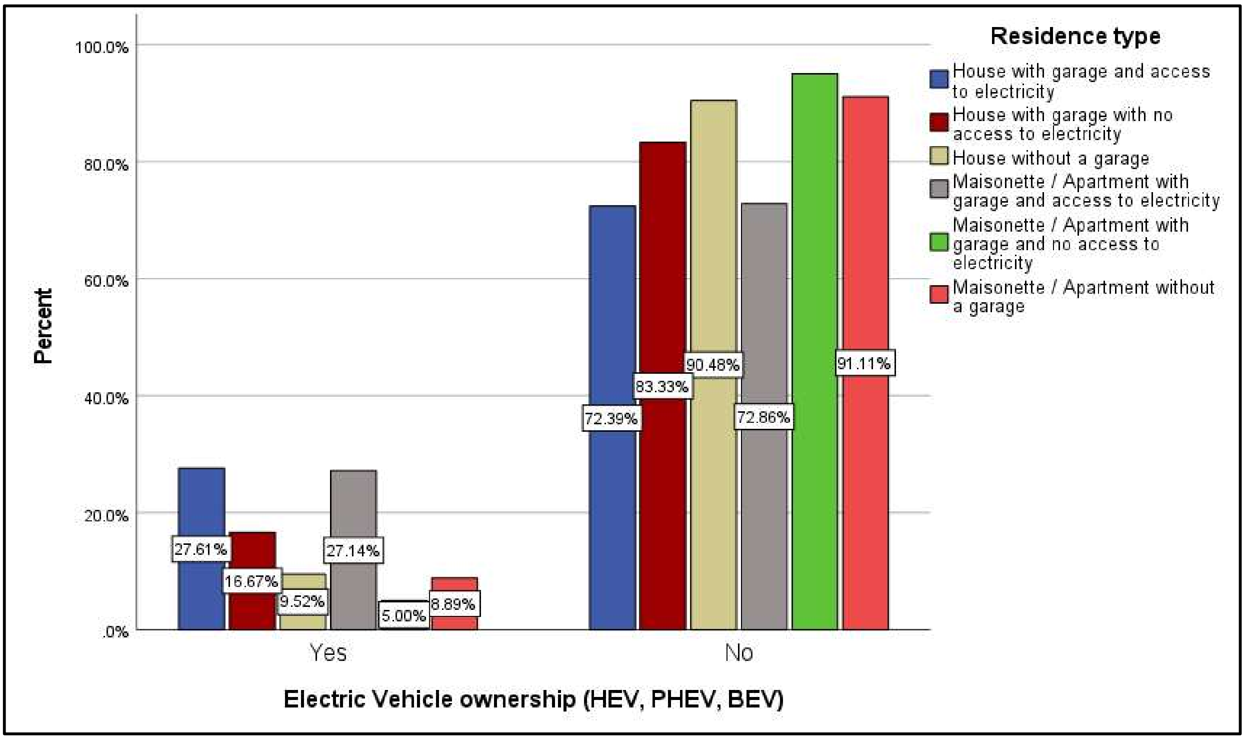

Figure 4.12: A graphical representation of the crosstabulation between the residence type and electric vehicle ownership.

The association between the total number of vehicles owned by the household and electric vehicle ownership

Aside from households that have more than four vehicles, Figure 4.13 shows a relative balance in the percentages when considering the relationship between electric vehicle ownership and the total number of vehicles owned by the household. Single vehicle households were the group with the second highest percentage (24.32%) of electric vehicle ownership following the group representing households with more than four vehicles (50%). Therefore, Figure 4.13 illustrates no significant association between the two variables under study. This was also confirmed by the Chi-Square test, where the p-value of 0.460 is larger than the 0.05 level of significance (see Appendix B, Tables B21 and B22).

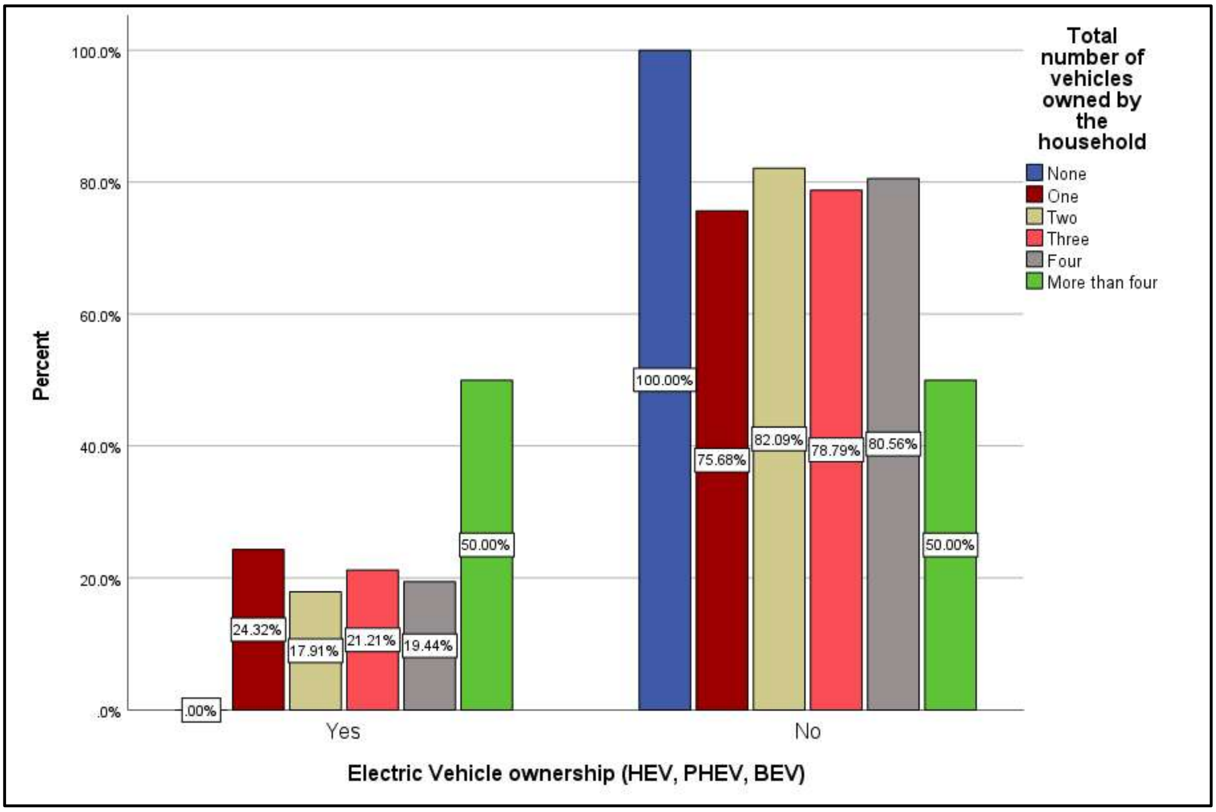

Figure 4.13: A graphical representation of the crosstabulation between the total number of vehicles owned by the household and electric vehicle ownership.

4.3. Evaluating knowledge and attitude towards electric vehicle adoption

Maltese consumers consider electric vehicles as a cleaner form of transport when compared to conventional vehicles. Over 50% of the participants strongly agree that running an electric vehicle emits less carbon dioxide when compared to internal combustion engine vehicles (see Appendix C, Table C1). However, Maltese consumers have mixed opinions (24.81% disagree and 33.25% agree) on whether driving an electric vehicle makes them proud that they are expressing environmental consciousness (see Appendix C, Table C2).

Likert scale results show that the economic aspect is an influential variable among Maltese consumers. Similar to Nixon and Saphores (2011), fuel cost is considered as an important attribute because 34.27% and 33.50% of the respondents, respectively, agree and strongly agree that fuel savings can encourage them to purchase an electric vehicle in the future. Over 32% of the respondents agree and 33.50% strongly agree that HEV and PHEV are more reliable due to the possibility of running such vehicles using an internal combustion engine (see Appendix C, Table C3).

A similar pattern can be observed when respondents considered purchase price and subsidies (see Table 4.1). In this case, the most popular choice was a new subsidised PHEV and keep the old ICE vehicle (32%), followed by a new unsubsidised HEV (22.8%). The option of purchasing a new subsidised BEV as a replacement of the old ICE vehicle was, on the other hand, the third most popular choice. When considering solely the purchase price, 35.81% of the participants agree to prefer the purchase of an HEV over PHEV and BEV due to the lower market value of the former (see Appendix C, Table C3). In spite of this, 45.52% and 26.85% of the respondents, respectively, agree and strongly agree that HEV and PHEV incur higher operational costs because they operate on both an internal combustion engine and a battery. In fact, when considering operational costs, participants prefer the purchase of a BEV over an HEV and a PHEV (see Appendix C, Table C3). Furthermore, 38.36% and 25.53% of the participants respectively agree and strongly agree that they prefer BEVs over PHEVs and HEVs because BEVs release no tailpipe emissions, therefore are considered as being more environmentally friendly (see Appendix C, Table C1). However, when considering purchase price, range, charging time and carbon dioxide emissions (see Table 4.2), HEVs (35.04%) resulted to be the most popular option followed by PHEV (29.92%), BEV (21.74%) and ICE vehicles (13.30%). Although consumers' electric vehicle type preference varies according to the situation presented in the Likert Scale, as previously stated (and shown in Figure 3.4), Maltese electric vehicle owners preferred the purchase of BEVs over HEVs and PHEVs.

Preferred type of future electric vehicle considering purchase price and subsidies		
	Frequency	Percent
New BEV, benefit from purchase subsidy and scrap old vehicle.	84	21.48
New PHEV, benefit from purchase subsidy and scrap old vehicle.	68	17.39
New BEV, benefit from purchase subsidy and keep the old ICE vehicle.	25	6.39
New PHEV, benefit from purchase subsidy and keep old ICE vehicle.	125	32.00
New HEV, no purchase subsidy.	89	22.8
Total	391	100.0

Table 4.1: Preferred type of future electric vehicle considering purchase price and subsidies.

Vehicle preference considering purchase price, range, charging time and carbon dioxide emissions			
		Frequency	Percent
Valid	BEV	85	21.74
	PHEV	117	29.92
	HEV	137	35.04
	ICE vehicle	52	13.30
	Total	391	100.00

Table 4.2: Vehicle preference considering purchase price, range, charging time and carbon dioxide emissions.

Affordability

Almost 44% of the participants state that the purchase of electric vehicles is only considered because currently, they are financially subsidised. Nevertheless, 34.53% and 42.71% of the respondents, respectively agree and strongly agree that although electric vehicles are subsidised by government, such vehicles are still considered unaffordable (see Appendix C, Table C4). This line of thought is evident in the following comments:

"I would like to purchase an electric vehicle, but they are too expensive. Manufacturers should lower prices and by doing so, more people including myself would invest in such a car. Climate change is no longer a myth, so everyone should take such an issue at heart."

"In my opinion, the idea of electric vehicles in Malta is still not taken seriously by the public, it's just a mentioned idea by authorities and there is an urge to change all of our cars to electric vehicles by 2030-35 but people are not willing to buy these cars as they are very expensive. An €11,000 subsidy, although quite a substantial amount, I don't think it is enough to encourage people to change to electric cars."

Government grants

Consumers expressed their concern about the fact that subsidies are not applied immediately at the time of the purchase but consumers have to wait for several months to receive them. Since consumers have to pay the actual vehicle price to the dealer, such vehicles result to be unaffordable for certain consumers as implied by the following respondents:

"I just bought a new car. Originally, I intended to buy an electric car (SMART) - a small car to replace my very small and reliable car - Subaru Vivio. The price was €28,500 - quite expensive for a 2-seater car but I was going to decide on it when I got to know about the €11,000 government scheme. When I did some HW and asked Transport Malta personnel about the scheme I was told that I have to pay the full amount first and that if funds are no longer available I will be risking and I won't receive the grant. I couldn't afford not being given the scheme, so I had to opt for a cheaper brand new ICE car. I went for an Aygo X, which is unfortunately bigger, it is automatic and it costed me €16,500. To motivate people to buy electric cars, the government needs to provide the scheme before."

"The price should be lowered when one makes the purchase because it's ok that you get your €11,000 back but, in these days, if I have to spend €35,000, I can use them on something I really need if my car is in perfect condition. So, I believe that if the price is automatically reduced to let's say €23,000 more people can afford it because they don't need to fork out the extra €11,000."

"The grant is to be settled at source and not wait for months to be refunded. We already have been waiting for more than 8 months for money we pocketed out and have been begging weekly and chasing to see when our money is going to be repaid back. This discourages many people since no one is happy to have 11,000 euros loaned to the government and end up begging to receive them back. This is what is causing uncertainty."

Over 61% of the participants agree that they are concerned that electric vehicles may be subject to a higher value depreciation when compared to internal combustion engine vehicles due to the continuous developments in technology (see Appendix C, Table C4). Battery swapping can represent a solution to reduce financial burden associated with electric vehicles. Over 43% of the respondents strongly agree that battery swapping may motivate them to purchase an electric vehicle because it reduces the initial vehicle price. Also, 46.04% of the respondents strongly agree that battery swapping reduces operational costs, making electric vehicles more economically viable (see Appendix C, Table C5).

42.71% of the respondents agree that the purchase of a second-hand electric vehicle is considered because second-hand electric vehicles are more affordable. Out of the three types of electric vehicles on the market, 37.85% of the respondents agree that a higher consideration is given to the purchase of a second-hand HEV when compared to a second-hand PHEV / BEV because HEVs are the most common second-hand electric vehicles in stock (see Appendix C, Table C6). Battery deterioration is an aspect that conditions consumers' choice when buying a second-hand electric vehicle. In fact, 51.41% of the participants agree that they are concerned about the level of battery deterioration in a second-hand electric vehicle. Furthermore, 37.34% and 20.20% of the respondents, respectively, agree and strongly agree that they prefer to buy a second-hand HEV over a second-hand BEV / PHEV due to concerns related to the high battery replacement cost of BEV / PHEV (see Appendix C, Table C6). Therefore, according to 51.66% of the respondents, battery swapping may solve any concerns related to battery deterioration (see Appendix C, Table C5).

Fiscal incentives aim to make electric vehicles more attractive to Maltese consumers, yet the latter are not fully aware of all existing fiscal incentives. Almost 34% and 49.87% of the participants, agree and strongly agree that they are aware about current fiscal grants associated with the purchase of an electric vehicle. Furthermore, 30.43% and 44.76% of the participants agree and strongly agree that they are aware that electric vehicle owners are exempted from registration tax and from paying road licence for the first 5 years and that from the sixth year onwards the licence fee amounts to €10 (see Appendix C, Table C7). On the other hand, 40.15% of the participants expressed a neutral point of view regarding the current incentive that exempts electric vehicle owners from paying a fee when accessing areas in Valletta under the Controlled Vehicular Access (CVA) system – a road pricing scheme introduced in 2007 to limit car traffic in the city's narrow, historic roads (see Appendix C, Table C7). A similar result was obtained (54.73% had a neutral opinion) when asking about knowledge regarding the availability of the three free government charging pillars (see Appendix C, Table C7).

Limited knowledge

Restricted knowledge regarding the field of electric mobility was also expressed in the survey, where 58.34% of the sample population agree that informative campaigns in the Maltese Islands related to the total cost of ownership of electric vehicles is still limited (see Appendix C, Table C4). This raises concerns among consumers, as expressed by the following survey participants:

"Considering our overpopulation and that most people already do not posses a garage, how will they charge their vehicle? How about parents driving their children to extra-curricular activities or simply running errands... will they have enough time to recharge their vehicle? What happens when some reckless irresponsible driver ends up with a flat battrey on the Maltese roads? What happens when multiples of them end up with a flat battrey in the rush hour on the Maltese roads?"

"More information needs to be given to the general public regarding different types of electric vehicles, pricing, charging etc. This can be done through seminars, short adverts on social media or tv. This is because there are misconceptions, and the general public lacks detailed knowledge."

The respondents' electric vehicle driving experience conditions the level of concern among the general public on the adoption of such vehicles. Just over 28% and 29.41% of the respondents, agree and strongly agree that they have concerns that the electric vehicle battery gets depleted before reaching destination. However, 19.18% of the respondents have a contrasting opinion (see Appendix C, Table C8). A solution to the aforementioned concern may be battery swapping. In fact, 41.69% of the respondents agree that battery swapping may reduce range anxiety (see Appendix C, Table C5). Almost 25% and 20.97% of the respondents, strongly disagree and disagree that driving electric vehicles is more complex when compared to conventional vehicles. Yet, individuals who never experienced such vehicles had a neutral opinion (46.80%) (see Appendix C, Table C8). A common concern among the sample population refers to the possible locations where vehicles can be serviced with 30.69% agree and 34.78% strongly agree that this is an issue (see Appendix C, Table C8). On the other hand, 48.85% of the respondents have a neutral opinion on concerns related to the safety of electric vehicles which include fires or accidents due to low operational sound. Neutral opinions were also prevalent (66.24%) when participants had to rate their awareness regarding the emissions associated with the production of electric vehicles versus the production of ICE vehicles (see Appendix C, Table C1). Also, 56.52% of the respondents had a neutral opinion on whether charging an electric vehicle may contribute to air pollution (see Appendix C, Table C1).

Charging locations

The need to plug-in electric vehicles (PHEV and BEV) for charging is considered by 25.06% (agree) and 36.83% (strongly agree) as unpractical (see Appendix C, Table C9). Furthermore, 37.85% and 24.04% of the participants, are respectively discouraged by the time taken to charge the battery of the electric vehicle (PHEV and BEV). Thus, home charging or having a charging point close to the residence is considered as a determinant variable when deciding on whether to buy an electric vehicle or not (58.82% strongly agree). Therefore, it is crucial to have sufficient charging points to cater for the consumer needs because 59.85% of the sample population strongly disagree that currently there are sufficient public charging points around the Maltese Islands (see Appendix C, Table C9).

"One can hardly expect the uptake of electric vehicles to increase unless first of all the public is reassured that there are enough charging points readily available at all times across the entire span of the Maltese Islands. Apart from public awareness about how electric vehicles operate and the maintenance costs implications the lack of proper roadside infrastructure to support this kind of vehicle fleet is certainly a major limiting factor."

"As a country we need many more charging points where you can charge the car battery because there are very few points at this stage. Also, an attractive subsidy should be given when a replacement of the battery is needed. Parking is so difficult for people without garages, so unless every parking space has a charging point, it's going to be very difficult to adopt electric vehicle usage without improvement on charging times."

"There is the need to introduce slow chargers in every street which do not need apps to operate, just pay for the service with a visa. There is no need of reinventing the wheel, the charging experience has to be really simple, that is one must replicate the fuel of a car experience."

Battery replacement cost

After considering the association between charging time and battery degradation, which is highest when using fast DC charging pillars, participants opted for slow home AC charging as the preferred charging option. This preference is evident among all participants, irrespective of their residence type. Furthermore, fast DC charging resulted to be the less popular option among the participants (see Figure 4.14). Therefore, this contrasts with the outcomes recorded by Philipsen et al. (2016) who stated that individuals who are not capable to charge the electric vehicle at home prefer fast charging facilities. The Chi-Square test produced a p-value which is less than 0.001, thus, smaller than the 0.05 level of significance. This shows that the association between the residence type and charging preference is significant (see Appendix B, tables B23 and B24).

Similar to Figure 4.14, Figure 4.15 shows clearly that slow home AC charging is the preferred charging option, irrespective to the usual budget participants have when buying a vehicle. Therefore, even more affluent participants are concerned about battery degradation and the associated replacement costs. Concerns related to the electric vehicle battery replacement costs are highlighted in the following comments:

"The cost to replace a battery is around €12,000 and the battery has a guarantee of 8 years. I cannot pay €35,000 for a car whereby it serves for only 8 years. I need peace of mind with regards to travelling."

"The battery price should be reduced. It takes me a year, in order to save €1,000, let alone saving €5,000. I will need to get a bank loan!"

The association between the usual budget when buying a vehicle and charging preference is significant because the Chi-Square test p-value of 0.011 is smaller than the 0.05 level of significance (see Appendix B, tables B25 and B26).

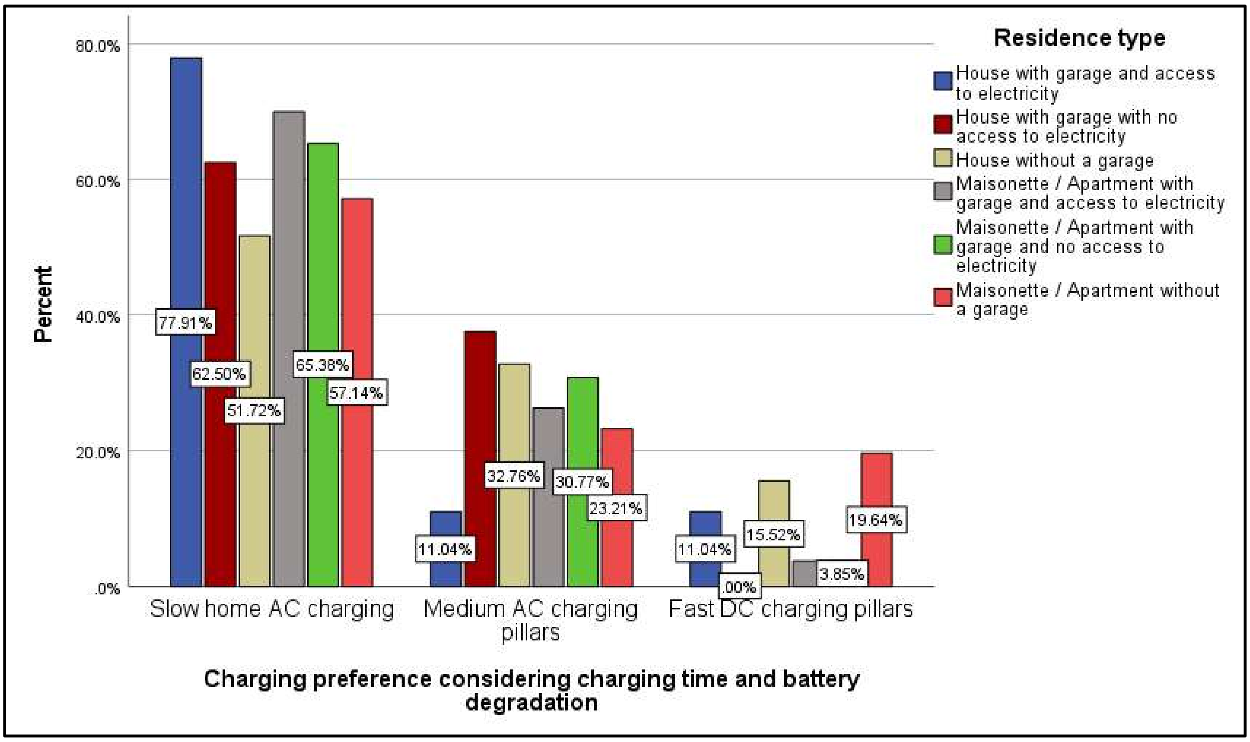

Figure 4.14: A graphical representation of the crosstabulation between the residence type and charging preference, considering charging time and battery degradation.

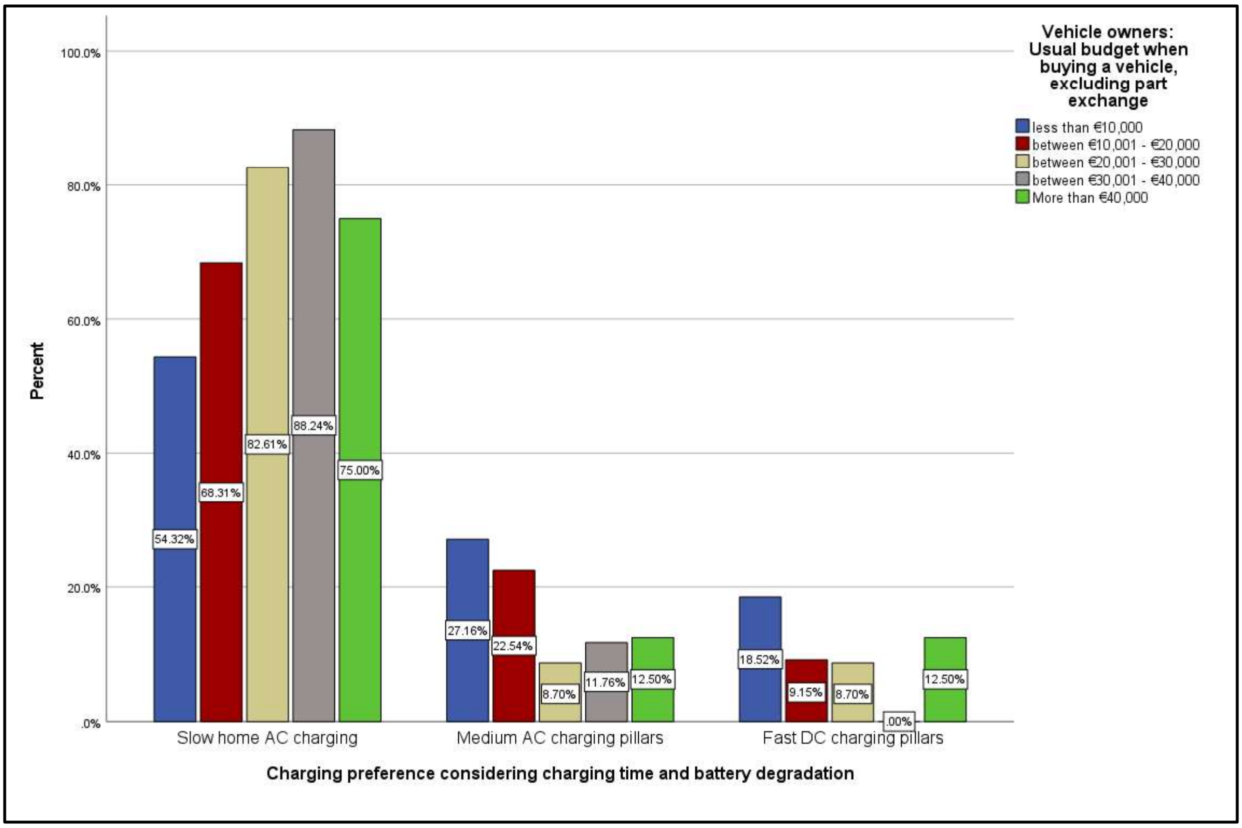

Figure 4.15: A graphical representation of the crosstabulation between the usual budget when buying a vehicle and charging preference.

Just over 46% of the participants strongly disagree that an eventual decision of adopting an electric vehicle or otherwise, is influenced by the opinion of relatives and friends. However, 40.15% of the participants agree that only an increase in electric vehicle adoption among the general public serves as a reassurance regarding the reliability of such vehicles (see Appendix C, Table C2). Nevertheless 51.66% of the respondents agree that free parking in highly congested areas, and a subsidised Gozo Channel ferry fee may motivate them to adopt an electric vehicle even though public opinion is still against the adoption of such vehicles (see Appendix C, Table C2).

When considering the possibility of introducing the 'Vehicle-to-Grid' system to increase electric vehicle adoption, 43.99% and 34.27% of the participants, respectively agree that the 'Vehicle-to-Grid' system is viable only for those people who can recharge the vehicle at home during off-peak hours (see Appendix C, Table C10). Also, 35.04% and 43.22% of the participants agree and strongly agree that the 'Vehicle-to-Grid' can only be successful if the system is introduced in the workplace where the vehicle is usually parked for a number of hours. However, 59.34% of the participants agree that the system will not be considered advantageous if it deteriorates the battery faster (see Appendix C, Table C10). 24.04% and 30.69% of the participants strongly disagree and disagree that they will highly consider the purchase of an electric vehicle in order to make profit from the 'Vehicle-to-Grid' system. Over 26% of the sampled population had a neutral opinion on the matter (see Appendix C, Table C10).

4.4. Regression analysis utilising the Multinomial logit model

The Multinomial logit model was based on the first six choice experiments presented in the questionnaire survey. In the model, four independent variables considered as important economic predictors: vehicle purchase price, road licence cost, fuel cost and battery replacement cost were associated with the type of vehicle purchase as the only dependent categorical variable. The three vehicle alternatives in the stated choice experiment were petrol, diesel and electric (HEV, PHEV and BEV) vehicles.

The purchase price when associated independently with electric vehicle purchase resulted to be significant (see Figures 4.10 and 4.11; Appendix B, Tables B15, B16, B17 and B18). Likert scale results, show that fuel / charging cost and battery cost are influential variables in decision-making (see Appendix C, Tables C3 and C6). However, unlike purchase price, fuel / charging and battery cost; road licence cost was not studied independently in this study. Since consumers often consider all economic variables during decision-making, the Multinomial Logit model provides a holistic approach because it evaluates the significance of these four economic predictors when consumers decide on the type of vehicle to purchase.

In the test of model effects (see Table 4.3) the p-value of every economic predictor; purchase price, road licence cost, fuel cost and battery replacement cost resulted to be 0.000, thus smaller than the 0.05 level of significance. This shows that each economic variable has a significant effect on consumers when choosing the type of vehicle to purchase. Table 4.3 shows that purchase price was the most effective variable since the Wald Chi-Square value of 117.150 is the largest value in the table. The second most effective variable is the battery replacement cost with a Wald Chi-Square value of 110.658, followed by road licence cost (108.154) and fuel / charging cost (91.522).

Tests of Model Effects			
	Wald Chi-Square	df	p-value
Purchase price	117.150	1	.000
Road licence	108.154	1	.000
Fuel / Charging cost	91.522	1	.000
Battery replacement cost	110.658	1	.000

Table 4.3: Test of model effects showing the significance of each predictor in determining the type of vehicle purchased.

The parameter of estimates table (see Table 4.4) was utilised in order to formulate the model which was in turn utilised for prediction purposes. Predictions were estimated utilising the formula below which was applied to every entry in the database representing the participants' choices in the six stated preference experiments. P_1 represents the probability that the participant opts for a petrol vehicle, p_2 represents the probability that the participant chooses a diesel vehicle while p_3 represents the probability that the participant goes for an electric vehicle. A worked example was also presented to explain how predictions were calculated by the SPSS program. The example was randomly chosen, and it reflects the choice the respondent made in the survey's third stated choice experiment (see Appendix A), where after considering the vehicle's purchase price, road licence cost, fuel cost and battery replacement cost of petrol, diesel and electric vehicles, the respondent opted for a diesel vehicle.

Parameter Estimates				
			95% Wald Confidence Interval	
Parameter	B	Std. Error	Lower	Upper
Threshold parameter 1	117.5048	10.0172	97.871	137.138
Threshold parameter 2	126.7270	10.5713	106.008	147.446
Purchase price	0.0055	0.0005	0.005	0.007
Road licence	-0.1525	0.0147	-0.181	-0.124
Fuel / Charging cost	-1.0977	0.1147	-1.323	-0.873
Battery replacement cost	0.2509	0.0239	0.204	0.298
(Scale)	1			

Table 4.4: The parameter of estimates table utilised to formulate the multinomial logit model.

$$\log_e\left(\frac{\sum_{i=1}^{j} p_i}{1-\sum_{i=1}^{j} p_i}\right)=\alpha_j-\beta x$$

$$\log_e\left(\frac{p_1}{1-p_1}\right)=117.5048-(0.0055\text{Price}-0.1525\text{Licence}-1.0977\text{Fuel}+0.2509\text{Battery})$$

$$\log_e\left(\frac{p_1+p_2}{1-(p_1+p_2)}\right)=126.727-(0.0055\text{Price}-0.1525\text{Licence}-1.0977\text{Fuel}+0.2509\text{Battery})$$

$$p_1+p_2+p_3=1$$

Worked example:

Price = 35000 Euro, Road Licence 560 Euro, Fuel cost = 10 Euro and Battery cost = 101 Euro

$$\log_e\left(\frac{p_1}{1-p_1}\right)=117.5048-[0.0055(35000)-0.1525(560)-1.0977(10)+0.2509(101)]=-3.9591$$

$$\frac{p_1}{1-p_1}=e^{-3.9591}=0.019$$

$$p_1=0.0191(1-p_1)$$

$$p_1=\frac{0.019}{1.019}=0.019$$

$$\log_e\left(\frac{p_1+p_2}{1-(p_1+p_2)}\right)=126.727-[0.0055(35000)-0.1525(560)-1.0977(10)+0.2509(101)]=5.2631$$

$$\frac{p_1+p_2}{1-(p_1+p_2)}=e^{5.2631}=193.079$$

$$p_1+p_2=193.079[1-(p_1+p_2)]$$

$$p_1+p_2=\frac{193.079}{194.079}=0.995$$

$$p_2=0.995-0.019=0.976$$

$$p_3=1-0.995=0.005$$

The scenario in the worked example shows that the participant is highly inclined to opting for a diesel vehicle because the individual has 1.9% chance of choosing a petrol vehicle (p_1), 97.6% chance of choosing a diesel vehicle (p_2) and 0.5% chance of choosing an electric vehicle (p_3).

The confusion table (see Table 4.5) demonstrates, the performance of the Multinomial Logit model in predicting the choice of vehicle (petrol, diesel, electric). According to Table 4.5, the model has an excellent outcome because the vehicle types predicted by the model are in their vast majority the same as the actual participant vehicle choice type. In fact, when accounting for the model's predictions associated with petrol vehicles, the model's predictions concur with 928 actual participant choices while it did not concur with the actual choices of 5 participants, 4 of whom opted for a diesel vehicle and 1 for an electric vehicle. Regarding diesel vehicles, the model's predictions concur with 384 actual participant choices while 11 choices were not predicted correctly. On the other hand, the model managed to predict all the actual electric vehicle choices. This means that when considering the percentage matching and percentage mismatching (see Table 4.6), the model performed 99.3% accurate predictions and only 0.7% inaccurate ones out of a total of 2,346 choices (391 participants x 6 choice experiments).

		Predicted Vehicle Choice		
		Petrol	Diesel	Electric
Actual Vehicle Choice	Petrol	928	0	0
	Diesel	4	384	0
	Electric	1	11	1018

Table 4.5: The confusion table showing the effectiveness of the model.

Percentage matching	**Percentage mismatching**
928 + 384 + 1018 = 2330	4 + 1 + 1 = 16
2330 ÷ 2346 = 0.993 / 99.3%	16 ÷ 2346 = 0.007 / 0.7%

Table 4.6: Percentage matching and percentage mismatching of the predictions performed by the Multinomial logit model.

4.5. Conclusion

This chapter comprises the results gathered from the online questionnaire survey. The socio-demographic variables of the sample population described in Chapter 3 were statistically analysed in this chapter with the help of crosstabulation in order to establish which socio-demographic determinant affect electric vehicle adoption. Chi-Square tests were also applied in order to test the significance of the association between each socio-demographic variable and electric vehicle adoption. This was followed by an analysis of the Likert Scale results intended to evaluate consumers' attitude, perceptions and knowledge related to the field of electric mobility. Furthermore, the Multinomial Logit model was used to test the effectiveness of purchase price, road licence cost, fuel/charging cost and battery replacement cost on consumers' decision-making.

In the next chapter the statistical output presented in this chapter will be discussed in detail referring to the literature review in chapter 2. The three research questions listed in chapter 3 will be addressed, in order to draw conclusions on the research outcome.

CHAPTER 5: DISCUSSION

5.1. Introduction

The literature review provided an overview of different socio-demographic variables which according to international literature influence electric vehicle adoption. In the same chapter reference was also made to past local research which studied electric vehicle adoption in the Maltese Islands. Therefore, this chapter aims to compare the outcomes of international and local research in the study area with the outcomes presented in Chapter 4: Results and Analysis. Comparisons will help in establishing any similarities and differences, as well as in obtaining a clear understanding of the current situation in the Maltese Islands regarding electric vehicle adoption. Comparisons with past local research will indicate if there has been any changes over time in the weight of certain attributes in determining the purchase or otherwise of electric vehicles as well as in answering the research questions outlined in the methodology chapter, again listed below:

1) Are the price and running costs determinant barriers in the uptake of electric vehicles amongst different socio-demographic segments of society?

2) Are fiscal incentives an effective means to promote the change from internal combustion engine vehicles to electric vehicles?

3) Is knowledge on electric vehicles being marketed in an effective manner to promote a positive attitude towards electric vehicles amongst the general public?

5.2. Demographic attributes and electric vehicle adoption

Gender

This study reveals that electric vehicle ownership is highest in the Western and Northern districts while lowest in the Southern Harbour district (see Figure 4.6). Literature shows that electric vehicle adopters are generally males (Hjorthol, 2013; Bjerkan et al., 2016; Plötz et al., 2014, Mohamed et al., 2016; Kim et al., 2014; Carley et al., 2013; Egbue and Long, 2012).

Although in Figure 4.2, male electric vehicle owners (24.47%) resulted to be higher when compared to female electric vehicle owners (15.50%), the Chi-Square test indicated that the association between gender and electric vehicle ownership is not significant because the p-value exceeded the 0.05 level of significance. This shows that although Figure 4.2 illustrates a higher percentage of male electric vehicle owners when compared to female electric vehicle owners, gender cannot be considered as an influential variable that conditions the purchase of electric vehicles. According to Figure 4.1, the highest percentage of electric vehicle owners are individuals that are 59 years of age and older. Therefore, the findings conform with the study performed by Esteves et al. (2021) who stated that middle and older age groups show more interest in electric vehicles when compared to the 18 – 29 age group. This study's outcome contrast with that of Jia and Chen (2021) who conclude that individuals of 55 years and older show less interest in hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). Furthermore, this study also has contrasting outcomes from studies performed by Hidrue et al. (2011); Ziegler (2012), Nayum et al. (2016), Plötz et al. (2014), Axsen et al. (2016), Parsons et al. (2014), Sheldon et al. (2017) and Cirillo et al. (2017), where electric vehicles resulted to be more popular amongst young to middle-aged individuals.

Age

Unlike the association between gender and electric vehicle ownership, the association between age and electric vehicle ownership turned out to be a significant association, indicating that age is an influential demographic variable that determines electric vehicle adoption. Since the Maltese Islands are experiencing an ageing population, similar to what was established by Young et al. (2017), the islands are expected to experience an increase in the number of elderly drivers in the coming future and consequently an increase in elderly electric vehicle adopters.

Marital status

This study shows that married individuals tend to have a higher tendency to own electric vehicles when compared to single individuals. Generally, married individuals live in multi-car households and have a higher combined income, thus electric vehicle adoption may be even more possible in such households (Jong et al., 2004; Dargay, 2002). This conforms with the studies performed by Jakobsson et al. (2016); Nayum et al. (2013); Figenbaum and Kolbenstvedt (2013) who also concluded that electric vehicle ownership tends to be associated with multi-car households. However, contrasting results emerged in this study because no significant association between the total number of vehicles owned by the household and electric vehicle ownership was identified.

Level of education

Literature shows that electric vehicle adopters have a high level of education (Hjorthol, 2013; Bjerkan et al., 2016; Plötz et al., 2014; Simsekoglu, 2018; Parsons et al., 2014; Kim et al., 2014 and Jia and Chen, 2021). In fact, according to Sovacool et al. (2018) electric vehicles were experienced or owned mostly by university graduates. Zhang et al. (2011), on the other hand, found opposite findings where consumers with a high level of education resulted to be less willing to purchase battery electric vehicles. Although Figure 4.4 illustrates that electric vehicle adoption is highest among respondents who have a certain level of education and lowest among respondents with a secondary education level, the Chi-Square test showed that the association between education level and electric vehicle adoption is not significant. Therefore, this shows that the education level of individuals does not influence electric vehicle adoption among survey respondents.

Employment and income

Contrasting outcomes emerged in literature regarding the association between employment and electric vehicle adoption. Morton et al. (2017) states that individuals with a full-time job tend to be early electric vehicle adopters, on the other hand, Christidis and Focas (2019) do not consider that employment is an influential factor. This study obtained a similar outcome to that of Christidis and Focas (2019) because the association between employment status and electric vehicle ownership resulted to be insignificant.

According to numerous sources (Hjorthol, 2013; Bjerkan et al., 2016; Nayum et al. 2016; Axsen et al., 2016; Christidis and Focas, 2019; Plötz et al., 2014; Jia and Chen, 2021) electric vehicle adopters earn a high income. Contrasting outcomes were obtained by Helveston et al. (2015) who found that high-income consumers are not keen to adopt an electric vehicle. Although participants in this study were not asked to declare their income, affluency was calculated according to the individual's usual vehicle purchase budget. A significant relationship was found between the individual's usual vehicle purchase budget and electric vehicle adoption. According to this study, the most affluent consumers, with a vehicle purchase budget of over €20,000 have a higher probability of adopting an electric vehicle when compared to consumers with a vehicle purchase budget less than €20,000. A significant association also emerged when examining the relationship between the usual vehicle purchase budget and number of vehicles owned by the household. This confirms the findings of Jong et al. (2004) and Dargay (2002) who state that multi-car households tend to have a higher income when compared to single-car households.

Regular residence by district

Electric vehicle ownership resulted to be highest among participants residing in the Western and Northern districts with the latter district having the highest percentage of electric vehicle owners who have two or more electric vehicles. Such findings conform with NSO (2022b), which identifies the Northern district as one of the districts with the highest disposable income per year. Therefore, in the coming years, there is a higher tendency that electric vehicle adopters increase at a faster rate in the Northern district when compared to other districts. On the other hand, this study shows that electric vehicle ownership is lowest among residents in the Southern Harbour district. Considering that according to NSO (2022b) the mentioned district experienced the highest increase in poverty levels, and that according to NSO (2022d; 2023b) the Southern Harbour is the district with the oldest licensed passenger vehicles, electric vehicle adoption among residents in the Southern Harbour district may take longer when compared to other districts.

Garage ownership and charging facilities

Helmus et al. (2018) state that high garage ownership permits electric vehicle owners to charge their vehicle regularly. In this study a significant association emerged between residence type and electric vehicle ownership, where a high percentage of electric vehicle owners live in a house with a garage and have access to electricity or live in a maisonette / apartment with a garage and have access to electricity. Low electric vehicle ownership was evident among participants who do not own a garage or own a garage with no access to electricity.

Although participants in this study consider the need to plug-in PHEV and BEV for charging purposes unpractical, home charging or having a charging point close to the residence is considered as a determining variable when deciding on the possibility to adopt an electric vehicle. Helmus et al. (2018) also state that where garage ownership is low, public charging facilities are needed and according to Figenbaum and Kolbenstvedt (2016) and Nicholas and Hall (2018) high-power charging stations should be located along travel routes to facilitate long trips. Although travel distances in the Maltese Islands are limited due to the small size of the islands, Maltese consumers believe that the current quantity of public charging pillars is not sufficient to cater for the consumer's needs. Various studies (Philipsen et al., 2015; Halbey et al., 2015; Egbue, 2012; Davidov and Pantoš, 2017) concluded that consumers consider the extra time spent to charge the electric vehicle or the time spent in detours to utilise a charging station as a barrier. A similar outcome emerged from this study since participants tend to be discouraged by the time consumed in order to charge the electric vehicle's battery.

Philipsen et al. (2016) reported that electric vehicle drivers, especially those who do not have a charging facility at home prefer fast charging facilities. The latter finding contrasts with the outcome of this study since in the choice experiment fast DC charging resulted to be the least preferred charging option among the participants, even among affluent participants. However, this outcome might have been influenced by the fact that electric vehicle ownership in the sample population is highest among individuals who have a garage with access to electricity. Therefore, owning a garage with access to electricity allows the individual to charge the electric vehicle when needed, utilising slow AC charging without necessitating the use of public charging pillars.

5.3. Price and running costs as barriers to the uptake of electric vehicles

Price and running costs were studied in order to investigate whether Maltese consumers consider these economic attributes as determining factors when deciding to purchase or otherwise an electric vehicle. Lieven et al. (2011), Liang et al. (2017) and Cui et al. (2021) stated that the vehicle price influences consumers during decision-making. This conforms with the outcome of this research where the large majority of the participants consider price as a determinant variable in their choice. This tendency emerged from the Multinomial logit model which showed a significant association between the vehicle's purchase price and electric vehicle adoption. In fact, in Table 4.3, purchase price was the most influential economic variable among survey participants who also considered road licence cost, fuel/charging cost and battery replacement cost when opting for the preferred vehicle in the stated choice experiments.

Vehicle owners resulted to have a higher purchase budget when compared to non-vehicle owners, some of whom are students who do not have a full-time job. As mentioned in section

5.2, purchase price sensitivity among Maltese consumers was confirmed in this research when associating the usual vehicle purchase budget with electric vehicle ownership. Most of the electric vehicle owners have a purchase budget of over €20,000. Furthermore, individuals with a high purchase budget resulted to have more than one electric vehicle in the household. Therefore, such outcomes are in line with Sierzchula et al. (2014), Larson et al. (2015) and Junquera et al. (2016) who state that the high purchase price represents a barrier for the purchase of electric vehicles.

This research shows that the majority of Maltese consumers have a vehicle purchase budget of less than €20,000, thus this can be indicative in explaining the low number of electric vehicle adopters in the Maltese Islands during the current scenario. This implies that Farrugia (2018) is correct when stating that when Maltese consumers opt for the purchase of an electric vehicle, they are willing to spend the same amount of money they usually spend for the purchase of a conventional vehicle. This study also shows that the introduction of battery swapping may motivate potential electric vehicle adopters to purchase an electric vehicle because battery swapping reduces the initial electric vehicle price, becoming more affordable to the general public.

Guo and Zhou (2019), Dua et al. (2019), Lim et al. (2015) imply that depreciation of the electric vehicles' market value caused by advancements in technology generates resale value anxiety among consumers. This is confirmed by this research study which shows that Maltese consumers are concerned that electric vehicles are subject to a higher depreciation when compared to internal combustion engine vehicles. Therefore, second-hand electric vehicles present a less risky investment and considered more affordable for a number of participants in this study. However, marketing second-hand electric vehicles will not help in lowering the national average of old vehicles (14.98 years) on the road (see Table 1.1). Similar to the timeframe when Ahomaa (2018) performed the study, Maltese consumers are still concerned about the degree of battery deterioration in a second-hand electric vehicle. In fact, consumers prefer a second-hand HEV over a second-hand BEV / PHEV, because the latter two types of electric vehicles incur a higher battery replacement cost due to the much larger in-built battery pack.

Battery deterioration concerns were also evident when studying the possibility of applying the Vehicle-to-Grid System to the Maltese scenario. In fact, participants did not consider the system advantageous if it increments the battery's deterioration process. Similarly, when comparing slow, medium and fast charging options, participants opted for slow home AC charging which leads to minimal battery degradation. Such outcome was also evident among participants whose usual vehicle budget is high, emphasising that battery degradation and the eventual high battery purchase price is a common concern among the general public. This conclusion is also supported by the outcome of the Multinomial logit model, where battery replacement cost was the second most influential predictor after purchase price (see Table 4.3). Battery swapping may solve such concerns because battery swapping was considered positively by a number of participants in solving issues related to battery deterioration and in avoiding the eventual high purchase price of a new battery.

Although Maltese consumers agree that HEVs and PHEVs are more reliable than BEVs due to the possibility of running the former two electric vehicles using an internal combustion engine, consumers associate HEVs and PHEVs with higher maintenance cost. This is evident among electric vehicle owners, most of whom opted to purchase a BEV from the three types of electric vehicles on the market. This research outcome is similar to what was reported by Ferguson et al. (2018) but contrasts with Jia and Chen (2021) who state that maintenance costs do not have a significant role in the choice of a vehicle. Apart from maintenance cost, this study also identifies concern among consumers on where to service an electric vehicle when the need arises. Such concern was already evident among Maltese consumers when Cuschieri (2020) and Farrugia (2018) performed their respective studies.

Fuel / charging cost were the least influential parameter in the Multinomial logit model, yet the model shows that it is still a significant economic parameter which determines the consumers' purchase decision (see Table 4.3). In fact, Maltese survey participants consider the purchase of a PHEV or a BEV to save fuel cost. Therefore, the outcome of this study confirms the findings of those researchers who state that fuel costs condition the utility of vehicles (Higgins et al., 2017; Axsen et al., 2015, Jensen et al., 2013). Therefore, for a successful campaign, electricity prices should be kept low because as Adhikari et al. (2020) explained, high electricity prices may discourage consumers to purchase electric vehicles. Furthermore, Mabit and Fosgerau (2011) also concluded that operational cost attributes influence vehicle purchase decisions. This research confirms Mabit and Fosgerau's (2011) findings because the Multinomial logit model besides from establishing that fuel cost and battery replacement cost are operational costs that have as significant effect on the consumers' vehicle purchase decision, the model also concluded that road licence cost is another significant parameter which determines the type of vehicle purchased by consumers.

5.4. Fiscal incentives as a means to promote the change

The Maltese government is subsidising the purchase of electric vehicles with the intent of reducing their initial purchase price, consequently making them more affordable to the general public. Although currently BEVs are the only type of electric vehicle that is being subsidised, in past financial schemes related to electric vehicle adoption, fiscal incentives were also applicable to the purchase of PHEVs. Therefore, as explained in the methodology, the stated choice experiment presented by the author in the questionnaire survey, considered fiscal incentives for both PHEVs and BEVs. This was done in order to study consumers' electric vehicle type preference when both electric vehicle types are subject to the same initial cost.

This study concludes that current financial subsidies are effective in encouraging the purchase of electric vehicles, because a number of participants admit that without financial subsidies, they would not consider the purchase of an electric vehicle. This outcome coincides with that of Bjerkan et al. (2016) who found that a reduction in the initial electric vehicle price resulted to be an effective measure in increasing electric vehicle adoption in Norway. However, contrasting results emerged between this study and that of Farrugia (2018) both of which were performed in the Maltese Islands among Maltese consumers of 18 years of age and older. Farrugia (2018) concluded that government subsides did not contribute to a positive attitude towards electric vehicle adoption. However, subsidies at the time of Farrugia (2018)'s research amounted to €7,000, which is much less than the maximum sum of €11,000 offered today. This implies that Sprei and Bauner (2011) are right when stating that high incentives are necessary to increase sales. Therefore, the author agrees with Ahomaa (2018) and Cuschieri (2020) when implying that electric vehicles will gain popularity among Maltese consumers when price parity between electric and ICE vehicles is achieved.

In an earlier study, Barbara (2011) states that when choosing among HEVs, PHEVs and BEVs, consumers who associate HEVs to conventional vehicles, tend to opt for an HEV instead of the other two electric vehicle options. When investigating the preferred type of future electric vehicle in the stated choice experiment, considering similar purchase prices and subsidies for

BEVs and PHEVs and no subsidies for HEVs, Maltese consumers, in this study opted for the purchase of a new PHEV but also in keeping the old ICE vehicle. HEVs which were presented in the same choice exercise with a slightly lower purchase price when compared to BEVs and PHEVs resulted to be the second most popular choice option. However, the result may have been influenced by the fact that the price difference between PHEV and HEV was minimal, thus individuals who are keen in investing in an electric vehicle preferred PHEVs over HEV because the former's larger battery pack allows a longer driving range when compared to the latter. Nonetheless, this result can be associated with Barbara (2011)'s findings since PHEV similar to HEV can operate utilising an internal combustion engine, indicating that PHEVs can be considered as being more similar to conventional vehicles when compared to BEVs. In fact, this research also shows that customers who are accustomed to internal combustion engine vehicles consider PHEVs and HEVs more reliable than BEVs. Additionally, the choice of keeping the old ICE vehicle is another indication that there is a common concern among Maltese potential electric vehicle consumers regarding the reliability of electric vehicles.

Garling and Thogersen (2001) report that in order to avoid traffic congestion issues, electric vehicles should be marketed as an alternative to an ICE vehicle and not as an additional vehicle to the household. Hence, although current government financial scheme of offering financial subsidies exclusively for the purchase of BEVs can be considered as an appropriate action to eradicate tailpipe emissions from transport, it does not necessarily mean that electric vehicles will substitute ICE vehicles on the road.

Bjerkan et al. (2016) found that road tolling exemptions, free parking and ferry tickets and access to bus lanes were significant incentives for half the sample studied. Same conclusions were presented by Langbroek et al. (2016) who state that electric vehicle use is encouraged when reducing the cost of electric vehicle trips. This coincides with the result of this research where Maltese consumers consider free parking in highly congested areas, and a subsidised Gozo Channel ferry fee as incentives that may persuade them to adopt an electric vehicle without considering public opinion on such vehicles. However, Langbroek et al. (2016) also states that incentives that reduce electric vehicles' trip costs do not cater for individuals who in spite of being interested in the purchase of such vehicles do not afford them. Therefore, introducing solely incentives targeting parking and Gozo Channel ferry fees, may not guarantee a rapid increase in the adoption of electric vehicles in the Maltese Islands. As previously mentioned, a number of Maltese consumers have a vehicle purchase budget which is lower than €20,000, which is by far lower than the current market value of electric vehicles, especially when considering the purchase price of brand new BEVs and PHEVs. Hence, fiscal incentives targeting solely parking and Gozo Channel ferry fees might not represent an equitable and effective solution in tackling the limited number of electric vehicles in the Maltese Islands. Such incentives should compliment other financial subsidies which aim in lowering the purchase price of electric vehicles.

5.5. The role of knowledge for an effective marketing strategy

In this study Maltese consumers consider informative campaigns in the Maltese Islands related to the total cost of ownership of electric vehicles as deficient. Furthermore, as stated in section 4.3, Maltese consumers are not fully aware about all fiscal incentives being offered. Contrary to Ahomaa (2018), in this study, consumers were well informed about fiscal incentives intended to reduce the initial purchase price of electric vehicles as well as about fiscal benefits associated with road licence. Similar to Pisani (2020), and as explained in section 5.4, awareness of such incentives is an effective means of increasing the purchase of electric vehicles. However, this study also shows that consumers lack awareness regarding fee exemptions when accessing areas in Valletta where the CVA system charges for access, and are also not well informed about the availability of three free government charging pillars. Berliner et al. (2019) argued that limited knowledge can represent a barrier for the adoption of electric vehicles. Furthermore, Lane and Potter (2007) explained that limited knowledge may lead to the development of misconceptions, triggering a negative attitude among consumers towards electric vehicles which according to Schleich (2009) may be caused when the total cost of ownership of such vehicles is calculated on heuristics.

Wang et al. (2018), Sung (2010) and Liu et al. (2018) infer that knowledgeable consumers perceive less risks, thus consider a product differently from individuals that lack knowledge. Also, Sierzchula et al. (2012) state that consumers are less willing to pay for an innovation which differs considerably from conventional technology. Since informative campaigns in the Maltese Islands are limited, knowledge on the total cost and attributes of electric vehicles depends mainly on consumer experience. Unfortunately, this study shows clearly that Maltese drivers who do not own an electric vehicle have limited experience in driving HEVs, PHEVs and BEVs. Therefore, this might explain why individuals may be hesitant to risk a large sum of money on a vehicle when uncertainty about the benefits of such vehicles is still high. Jabeen et al. (2012) and Skippon and Garwood (2011) state that experienced drivers are more willing to pay a high price for an electric vehicle when compared to inexperienced individuals. Thus, considering that current financial incentives in the Maltese Islands result to be effective in increasing electric vehicle adoption, an effective promotional campaign is essential to market electric vehicles, incrementing the sales and consequently increasing experience among Maltese consumers.

According to Dumortier et al. (2015), the provision of information on electric vehicles is a low-cost tool to market such vehicles which can be done utilising informative labels (Nixon and Saphores, 2011) related to the total cost of operation of such vehicles. Furthermore, in order to increase the percentage of experienced electric vehicle drivers, an opportunity to perform a test drive of such vehicles may also contribute positively to decision making, because according to Bandhold et al. (2009), trialability reduces concerns related to driving range and battery capacity.

She et al. (2017) pointed out that experience does not always contribute to an increase in electric vehicle adoption. According to Bart et al. (2015) individuals' decision on whether to purchase or not an electric vehicle is influenced by the information obtained from other individuals. Additionally, Egbue and Long (2012) and Eppstein et al. (2011) state that if consumers do not observe a number of electric vehicles around them, subsidies may have minimal effect on the sales of such vehicles. Similar to Barbara (2011) and unlike Cuschieri (2020) this study shows that the decision of purchasing an electric vehicle or otherwise is not dictated by the opinion of relatives and friends. Nonetheless, the conclusions presented by Bart et al. (2015); Egbue and Long (2012) and Eppstein et al. (2011) comply with the findings of this study because participants agree that an increase in the number of electric vehicles on the road puts their mind at rest regarding the reliability of such vehicles. Furthermore, this demonstrates that as stated by Thøgersen (2006), individuals compare their reasoning and action with those of other individuals to follow social norms based on perceived expectations.

Jiang et al. (2021) mention that electric vehicles may be subject to fire accidents when parked, during charging as well while running on the road. Moreover, Everett et al. (2010) imply that electric vehicles can be dangerous to pedestrians and cyclists as well to blind people (Emerson et al., 2011) due to their low operational sound. The majority of the participants in this study had a neutral opinion on the matter indicating uncertainty about the mentioned risks. Cui et al. (2021) imply that since electric vehicles are considered environmentally friendly vehicles, individuals may be motivated to adopt such vehicles in order to gain acknowledgement and respect from other individuals in society. However, this study shows that Maltese consumers have conflicting opinions on whether driving an electric vehicle makes them proud that they are expressing environmental consciousness (see Appendix C, Table C2). This result may be a consequence of the fact that participants in this study showed limited knowledge regarding the environmental impacts of electric vehicles. Although participants agree that running an electric vehicle emits less carbon dioxide when compared to internal combustion engine vehicles, they are not certain about the emissions associated with the production of electric vehicles and on whether charging an electric vehicle contributes to air pollution.

According to Truffer et al. (2000) electric vehicles are more appealing to that segment of society that is keen on environmental matters. This study shows that Maltese consumers care about the environment because out of the three types of electric vehicles BEVs are preferred over PHEVs and HEVs because BEVs release no tailpipe emissions, thus considered more environmentally friendly. In fact, as previously mentioned, BEV result to be the most popular type of electric vehicle among electric vehicle owners. However, as seen in Table 4.2, when considering purchase price, range, charging time and carbon dioxide emissions, participants preferred HEV over the other vehicle options; ICE vehicle, PHEV and BEV.

Although HEVs release tailpipe emissions when running on the internal combustion engine, the respondents' choice was dictated by the vehicles purchase price. In the choice experiment an ICE vehicle and an HEV had a cost of €22,000 while the PHEV and the BEV had a cost of €35,000. Additionally, it is important to note that although the HEV and the ICE vehicle were presented in the choice experiment with the same purchase price of €22,000, HEV with 75% carbon dioxide emissions was preferred over the ICE vehicle associated with 100% carbon dioxide emissions. This shows clearly that although Maltese consumers are keen on environmental matters, the high purchase price of electric vehicles, especially that of BEVs results to be a determining barrier which is currently conditioning the adoption of electric vehicles.

5.6. Conclusion

This chapter examined the research outcomes presented in Chapter 4 which were in turn obtained utilising the data collection methods explained in Chapter 3. Throughout this chapter the research outcomes were interpreted with reference to the three research questions. Hence, following the above discussion, price and running costs, result to be determinant barriers in the uptake of electric vehicles amongst different socio-demographic segments of society. Therefore, current financial incentives should be renewed until the purchase price of electric vehicles lowers. However, it is also fundamental that knowledge on the total cost of ownership of electric vehicle increases among the general public, considering that electric vehicle driving experience among the general public is still limited.

In the following chapter, the research outcomes discussed in this chapter will be summarised so that a general conclusion for this study is formulated. This will serve in recommending possible effective future strategies that can help in increasing the amount of electric vehicle adopters in the Maltese Islands.

CHAPTER 6: CONCLUSION

6.1. Introduction

This concluding chapter summarises the main outcomes of the research study, suggesting also possible policy recommendations that may help in increasing electric vehicle adoption in the Maltese Islands among different socio-demographic sectors in society. An evaluation of the difficulties encountered throughout the study is performed, also establishing the limitations of the study. Finally, this is followed by recommendations for future research in the area of electric mobility which can be considered by future researchers to increment academic information in the field.

6.2. Summary of the research findings

This research aimed at studying the effectiveness of purchase price and operational costs on electric vehicle adoption in the Maltese Islands. Throughout the study, the impact of current fiscal incentives as well as the role of knowledge on consumers' attitude in influencing decision-making were assessed by the inclusion of Likert Scales and stated choice experiments in the questionnaire survey. Likert Scales and stated choice experiments helped in observing how consumer attitudes change according to different circumstances, providing valuable information to establish the most significant perceptions, patterns and trends towards electric vehicle adoption among Maltese consumers under the current scenario. This study also identified the most influential socio-demographic variables which condition decision-making, facilitating the development of possible future policy recommendations (section 6.3) which can help in increasing the sales of electric vehicles among potential consumers.

This research confirms that economic factors are limiting potential consumers from purchasing electric vehicles. The electric vehicle's purchase price and battery replacement cost represent a major barrier among Maltese consumers, in fact, fiscal incentives are considered effective in reducing the financial burden. Nonetheless, limited knowledge and experience among a number of consumers is generating uncertainty about the reliability of electric vehicles. Maltese consumers express environment concern because BEVs resulted to be the preferred electric vehicle option due to the release of no tailpipe emissions. However, when consumers considered purchase price, range, charging time and carbon dioxide emissions, consumers opted for an HEV which is the electric vehicle that is most similar to a conventional vehicle. Furthermore, even when consumers opt for the purchase of a second-hand electric vehicle, HEVs also resulted to be the preferred vehicle option. Second-hand HEVs are considered as more affordable and less risky when compared to second-hand PHEVs and BEVs, especially when considering battery deterioration.

In this study electric vehicle ownership resulted to be highest in the Western and Northern district while lowest in the Southern Harbour district. Unlike other literature in the field, this study concludes that gender and employment status are not significant determinant socio-demographic variables in electric vehicle adoption. This study indicates that electric vehicle ownership is highest among middle and elderly age groups. Yet, this outcome contrasts with those studies which concluded that electric vehicles are adopted mostly by young to middle-aged individuals. Numerous studies concluded that electric vehicles are associated with high earners. This fact emerged also in this research where individuals who have a vehicle purchase budget of over €20,000 tend to adopt electric vehicles. The purchase budget may be also influenced by marital status because married couples tend to have a higher combined purchase budget when compared to single individuals. In this research a significant association between marital status and electric vehicle purchase is established. Furthermore, this study concludes that garage ownership is an effective variable that conditions consumers because a garage with access to electricity permits electric vehicle owners to charge their vehicle regularly and at their convenience. This explains why electric vehicle ownership under current scenario is highest among individuals who own a garage that has access to electricity. Thus, low garage ownership requires the introduction of numerous charging pillars to meet consumer needs and minimise range anxiety. This study shows clearly that the number of charging pillars currently available to Maltese consumers is insufficient and that immediate action is required to facilitate potential consumers to purchase an electric vehicle even if they do not own a garage.

6.3. Policy recommendations

This research shows that the purchase price is the variable which mostly influences Maltese consumers when deciding on whether to purchase an internal combustion engine or an electric vehicle. This conclusion was also confirmed through the use of a Multinomial logit model. Therefore, unless the market value of new electric vehicles decreases, current financial subsidies result to be essential in order to encourage the purchase of such vehicles. Hence, it is not recommended to reduce the subsidised sum of €11,000 because when the government grant amounted to €7,000, the grant resulted to be uninfluential during decision-making. However, although the study shows that current financial subsidies are attracting potential consumers, when buying an electric vehicle, consumers have to pay the dealer the actual vehicle price. This means that if the consumer is not capable to pay the full price, the individual may be discouraged from buying an electric vehicle and instead opt for the purchase of an internal combustion engine vehicle which has a cheaper and a more affordable market value. According to the general comments in this survey, certain participants are not keen to spend a large sum of money in order to buy a new electric vehicle because concerns related to such investment are still considerable, making electric vehicle purchase a risky investment among a number of Maltese potential consumers. Another drawback is that consumers who opt to purchase an electric vehicle receive the subsidised sum of money six to eight months after the vehicle has been purchased, conditioning the consumers' initial purchase budget. A possible solution to this problem is to assign the subsidised sum of money directly to the car dealers so that consumers pay straight away for a subsidised vehicle.

Battery replacement cost is a detemining barrier that conditions electric vehicle adoption. Although the in-built battery of new electric vehicles is covered by an 8-year manufacturer guarantee, this research shows that Maltese consumers are still sceptical on the reliability of such vehicles. Participants showed concern about the driving range of electric vehicles and on the eventual high battery replacement cost, rendering it unworthy considering that the vehicle's market value depreciates on a yearly basis. Thus, the introduction of battery swapping stations may overcome the mentioned concerns as well contribute to reduce the vehicle's purchase price. Furthermore, battery swapping can help consumers to keep their vehicle for a longer time. Battery swapping stations may also be beneficial in a situation where an electric vehicle stops operating all of a sudden due to battery failure. Such stations can provide battery delivery and replacement in the location where the vehicle stops avoiding traffic congestion, especially on busy roads.

Although fuel / charging cost emerged to be significant in influencing the type of vehicle purchased, when considering the results obtained from the Multinomial logit model, fuel /

charging cost resulted to be the less effective economic factor, when compared to purchase price, road licence cost and battery replacement cost. Therefore, unless fuel costs for internal combustion engine vehicles increases exorbitantly, campaigns promoting electric vehicle adoption based on fuel economy may not be successful. However, an exorbitant increase in fuel costs tends to be unlikely, when considering disagreement on the complete phase-out of fossil fuels during the 28th United Nations Conference of the Parties (COP 28) held between 30th November and 12th December 2023. Road licence cost was another economic factor which according to the Multinomial logit model affects consumers during the decision-making process. Currently electric vehicle adopters are exempted from paying any road licence fee for the first five years and afterwards pay only €10 anually. Yet, although consumers owning ICE vehicles pay higher licence fees, the latter are not discouraged from purchasing ICE vehicles. Therefore, the provision of more incentives that prioritise electric vehicles over ICE vehicles such as free and priority parking for electric vehicles in highly congested environments or a subsidised Gozo Channel Ferry fee may encourage more adopters.

Although financial incentives indirectly serve as disincentives for ICE vehicles, authorities may consider the implementation of financial and/or non-financial disincentives directly on the use of ICE vehicles. For example, restricting ICE vehicle usage to an established amount of mileage per week or restrict the usage of such vehicles in highly congested locations (e.g. Low Emission Zones). Nonetheless, financial and non-financial incentives and disincentives are successful only if such initiatives are accompanied by improvements in the current charging infrastructure to support an increased number of electric vehicles. This implies that apart from increasing the amount of charging pillars available to the public, to cater for the increased number of individuals who do not own a garage, it is also highly essential to cater for the expected increase in the demand of energy. Furthermore, monitoring and enforcement should be applied to ICE vehicle owners who park their vehicle in the parking slots dedicated to electric vehicle charging.

6.4. Research limitations and difficulties encountered

Data collection was carried out adopting simple random sampling, allowing any individual who encountered the online survey link and was willing to answer the questionnaire to participate in the study. Although this sampling method contributed to gather valuable information from different socio-demographic groups, Gozitan participants resulted to be low in number. Thus, the outcome of the study does not fully represent the Gozitan perceptions towards electric vehicle adoption. Maybe future research on the area can adopt a systematic sampling technique that ascertains that a representative sample is studied from each district, avoiding the issue of underrepresentation that emerged in this study with regards to the Gozo district. Reaching the minimum sample size number of 384 respondents established by the sample size calculator was a major concern in the initial stages of data collection. Unexpectedly, participants showed high interest in the study, some of whom admitted that the questionnaire served as a learning curve due to the acquisition of knowledge and information which they were not aware of. Despite data collection consumed a lot of time, managing to obtain feedback from 391 participants who provided the necessary information which facilitated the estabilishment of associations and in drawing conclusions brought great satisfaction during the conduct of the research.

6.5. Recommendations for further research

Research related to electric vehicle adoption in the Maltese Islands is still limited, thus there are potential research gaps that can be researched in the future. Aside from the influence of purchase price, operational cost, financial incentives and knowledge on electric vehicle adoption addressed in this research, future studies can cater for the effectivity of the vehicle's brand in determining the type of electric vehicle purchase. Certain vehicle brands are considered by consumers more reliable than others, though they tend to be more expensive; so the researcher can investigate whether potential consumers are ready to pay more money to purchase a vehicle manufactured by their desired manufacturer. Furthermore, such research can be useful in determining which vehicle brands have the highest market potential contributing to an increase in sales. Although financial incentives may encourage consumers in purchasing electric vehicles, some literature point to the fact that subsidies benefit the most affluent people. This study confirms that although financial subsidies are effective in attracting consumers, a number of Maltese consumers still consider electric vehicles' price too expensive, thus not affordable to buy. Therefore, future studies can consider equity issues and research effective ways and means, including financial incentives which can facilitate the purchase of such vehicles by all potential consumers.

Although the influence of charging on electric vehicle adoption was considered in this study, future research can explore the impact of the location of charging pillars on electric vehicle adoption. Such research can indicate the maximum distance potential electric vehicle owners are ready to travel to charge their vehicle. The outcome of such research will be critical in the planning for future charging pillars. Further consideration may also be given to the possibility of introducing the vehicle-to-grid system which was marginally explored in this study. Moreover, future researchers may also consider the same research questions addressed in this study since this can permit comparisons between this research outcome and future research finds, outlining similarities and changes throughout time, as techology improves. Therefore, the findings will not only represent an asset to academic literature but can also aid in identifying long term solutions which contribute to effective future planning.

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APPENDICES

Appendix A: Questionnaire Survey

Dear participant,

My name is Emmanuel Buttigieg and I am currently reading for a Master of Science in Sustainable Development at the University of Malta. As part of my course, I am conducting a 15 - 20 minute survey for my dissertation titled: "Towards a zero-carbon future. Investigating the barriers that are limiting the adoption of electric vehicles in the Maltese Islands." This research conforms with the University of Malta Research code of practice and research ethics review procedures. Your participation in the survey is purely voluntary and you can withdraw at any time. By participating in this survey, you are consenting that the information given will be utilised by the researcher for analysis purposes. All responses will be completely anonymous and will only be utilised for the purpose of the study, thus your participation will be highly valued.

Interested participants should reside in Malta and be 18 years of age and older.
If you have any queries or concerns do not hesitate to contact me via email on emmanuel.buttigieg.04@um.edu.mt or my supervisor Prof. Maria Attard on maria.attard@um.edu.mt.

Thank you very much for your time and consideration.

Acronyms and definitions of the three types of electric vehicles

BEVs - Battery Electric Vehicles
Electric vehicles that operate utilizing only the in-built battery which has to be charged.

HEVs - Hybrid Electric Vehicles
HEVs operate on both an internal combustion engine and an electric motor that uses energy stored in the battery which charges by the vehicle's braking system.

PHEVs - Plug-in Hybrid Electric Vehicles
PHEVs operate on both an internal combustion engine and an electric motor that uses energy stored in the battery. The battery is charged either by the braking system or by plugging to an electric charging point.

Demography

1) Age

18 - 28 years	
19 - 38 years	
39 - 48 years	
49 - 58 years	
59 - 65 years	
65+ years	

2) Gender

Male	
Female	
Other	

3) Marital Status

Single	
Married	
Widowed	
Separated	
Divorced	
Other	

4) Tick the district where your regular residence is located.

Southern Harbour District	Birgu, Bormla, Fgura, Floriana, Senglea, Kalkara, Luqa, Ħal Farruġ, Marsa, Paola, Santa Luċija, Tarxien, Valletta, Xgħajra, Żabbar
Northern Harbour District	Birkirkara, Fleur-de-Lys, Swatar, Gżira, Ħamrun, Imsida, Gwardamanġa, Pembroke, Pietà, Ħal Qormi, San Ġiljan, Paceville, Balluta, San Ġwann, Kappara, Santa Venera, Sliema, Swieqi, Madliena, Ta' Xbiex
South-Eastern District	Birżebbuġa, Ħal Għaxaq, Gudja, Ħal Kirkop, Marsaskala, Marsaxlokk, Imqabba, Qrendi, Ħal Safi, Żejtun, Żurrieq
Western District	Ħ'Attard, Ħal Balzan, Ħad-Dingli, L-Iklin, Ħal Lija, Imdina, Imtarfa, Rabat, Baħrija, Tal-Virtù, Siġġiewi, Ħaż-Żebbuġ
Northern District	Għargħur, Mellieħa, Manikata, Imġarr, Mosta, Naxxar, Baħar iċ-Ċagħaq, San Pawl il-Baħar, Buġibba, Qawra Burmarrad
Gozo and Comino District	Fontana, Għajnsielem, Comino, Għarb, Għasri, Kerċem, Munxar, Nadur, Qala, San Lawrenz, Sannat, Xagħra, Xewkija, Rabat (Victoria), Iż-Żebbuġ

Southern Harbour District	
Northern Harbour District	
South-Eastern Harbour District	
Western District	
Northern District	
Gozo and Comino District	

5) What is your education level?

Primary education	
Secondary education	
Sixth form education	
Undergraduate qualification (certificate, diploma, Bachelor's degree)	
Postgraduate qualification (certificate, diploma, Master degree, Ph.D)	
Other	

6) What is your employment status?

Employed	
Unemployed	
Retired	
Student and also a part-time employee	
Student performing no part-time jobs	
Other	

7) Which statement explains best the type of property where you live?

House with garage and access to electricity	
House with garage with no access to electricity	
House without a garage	
Maisonette / Apartment with garage and access to electricity	
Maisonette / Apartment with garage and no access to electricity	
Maisonette / Apartment without a garage	
Other	

8) What is the total number of vehicles in the household?

None	
One	
Two	
Three	
Four	
Other	

9) How many electric vehicles (HEV, PHEV, BEV) are owned by your household?

None	
One	
Two	
Three	
Other	

10) Do you own at least one vehicle?

Yes		Skip to question 11
No		Skip to question 13

Vehicle ownership

11) Without taking into consideration part exchange options, how much is your usual budget when buying a vehicle.

less than €10,000	
between €10,001 - €20,000	
between €20,001 - €30,000	
between €30,001 - €40,000	
More than €40,000	

12) Do you own any of the following types of electric vehicles: hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV) and battery electric vehicles (BEV)?

Yes		Skip to question 15
No		Skip to question 17

No vehicle ownership

13) If you were to purchase a vehicle without taking into consideration part exchange options, how much is your budget to buy a vehicle (second-hand or new)?

less than €10,000	
between €10,001 - €20,000	
between €20,001 - €30,000	
between €30,001 - €40,000	
More than €40,000	

14) If you were to purchase a vehicle, which type of vehicle will you buy in the future?

Internal combustion engine vehicle (ICE)	Skip to question 17
Hybrid electric vehicle (HEV)	Skip to question 17
Plug-in hybrid electric vehicle (PHEV)	Skip to question 17
Battery electric vehicle (BEV)	Skip to question 17

Electric vehicle ownership

15) Which type of electric vehicle do you own?

Hybrid electric vehicle (HEV) only	
Plug-in hybrid electric vehicle (PHEV) only	
Battery electric vehicle (BEV) only	
Both hybrid electric vehicle (HEV) and plug-in hybrid electric vehicle (PHEV)	
Both hybrid electric vehicle (HEV) and battery electric vehicle (BEV)	
Both plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV)	

16) Was the vehicle price a determinant factor when deciding whether to buy a brand new or a second-hand electric vehicle?

Yes		Skip to question 19
No		Skip to question 19

No electric vehicle ownership

17) Select your driving experience as regards the following types of electric vehicles.

	Never	Only once	More than once
HEV			
PHEV			
BEV			

18) If you were to purchase an electric vehicle will the vehicle price, be a determinant factor in your decision?

Yes	
No	
Other	

Attitude and Knowledge

Kindly rate the following statements according to the extent which such statements reflect your opinion.

BEVs - Battery Electric Vehicles
Electric vehicles that operate utilising only the in-built battery which has to be charged.

HEVs - Hybrid Electric Vehicles
HEVs operate on both an internal combustion engine and an electric motor that uses energy stored in the battery which charges by the vehicle's braking system.

PHEVs - Plug-in Hybrid Electric Vehicles
PHEVs operate on both an internal combustion engine and an electric motor that uses energy stored in the battery. The battery is charged either by the braking system or by plugging to an electric charging point.

19) Rate to what extent do you agree with the following statements related to the different types of electric vehicles on the market.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I consider buying a PHEV / BEV as my next car to save fuel costs.					
Both HEVs and PHEVs incur higher maintenance costs when compared to BEVs because both vehicles have an internal combustion engine, an electric motor and a battery while BEVs are not equipped with an internal combustion engine.					
Both HEVs and PHEVs are more reliable than BEVs since they can run an internal combustion engine.					
I prefer a HEVs over BEVs and PHEVs because HEVs have a lower market price.					

20) How aware are you about the following benefits related to electric vehicle adoption?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Currently, individuals that buy a BEV can benefit from a grant of €11,000 and an extra €1,000 when scrapping an internal combustion engine vehicle which is 10 years and older.					
BEV and PHEV adopters are exempted from registration tax and from paying road licence for the first 5 years. From the sixth year onwards the licence fee amounts to €10.					
Electric vehicle owners do not pay any fee when accessing areas in Valletta controlled by the Circular Vehicular Access (CVA) system.					
A total of 3 government solar charging stations can be utilised to charge an electric vehicle for free.					

21) Rate to what extent do you agree with the following statements related to the impacts of electric vehicles on the environment.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Running an electric vehicle emits less carbon dioxide when compared to internal combustion engine vehicles.					
I prefer BEVs over PHEVs and HEVs because BEVs release no tailpipe emissions, therefore are more environmentally friendly.					
The emissions released during the production of electric vehicles tends to be higher when compared to the emissions released during the production of internal combustion engine vehicles.					
Charging an electric vehicle may contribute to air pollution.					

22) Rate to what extent do you agree with the following statements on electric vehicle price and running costs.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I consider the purchase of electric vehicles only because they are financially subsidised.					
Although electric vehicles are subsidised by the government, I still consider such vehicles unaffordable.					
I am concerned that electric vehicles are subject to a higher value depreciation when compared to internal combustion engine vehicles due to continuous developments in technology.					
Informative campaigns in the Maltese Island related to the electric vehicle total cost of ownership is still limited.					

23) Rate to what extent do you agree with the following statements related to the preferred type of second-hand electric vehicles.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I consider the purchase of a second-hand electric vehicle because it is more affordable.					
I consider the purchase of a second-hand HEV and not a second-hand PHEV / BEV because HEVs are the most common second-hand electric vehicles in stock.					
I prefer to purchase second-hand vehicles but I am concerned about the level of battery deterioration in a second-hand electric vehicle.					
I prefer to buy a second-hand HEV over a second-hand BEV / PHEV because I am concerned about the high battery replacement cost of BEV / PHEV.					

24) Rate to what extent do you consider the following concerns as barriers when deciding about the purchase of an electric vehicle?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am concerned that the electric vehicle battery gets depleted before reaching destination.					
Electric vehicles are more complicated to drive when compared to conventional vehicles.					
I am concerned about where to service an electric vehicle when the need arises.					
I am concerned about the safety of electric vehicles such as fires or accidents due to low operational sound.					

25) Rate at what extent do you consider the following concerns associated with charging as barriers when deciding to purchase an electric vehicle?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The need to plug-in the vehicle for charging purposes makes battery electric vehicles very unpractical for use in everyday life.					
I am discouraged by the time taken to charge the battery of the electric vehicle (PHEV / BEV).					
I think there are sufficient public charging points around the Maltese Islands.					
Home charging or having a charging point close to my residence is a determinant variable when deciding on whether to buy an electric vehicle or not.					

26) Rate to what extent do you agree with the following situations in influencing your attitude towards the purchase of an electric vehicle.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The decision of adopting an electric vehicle or otherwise is influenced by the opinion of relatives and friends.					
Only an increase in electric vehicle adoption among the general public reassures me on the reliability of electric vehicles.					
Driving an electric vehicle makes me proud since it expresses environmental consciousness.					
Free parking in highly congested areas, and a subsidised Gozo Channel ferry fee can motivate me to adopt an electric vehicle even though public opinion is against the adoption of such vehicles.					

27) The 'Vehicle-to-Grid' system gives the opportunity to sell power stored in the electric vehicle battery to the electricity grid. Such system can be utilised in order to sell power during peak hours when electricity prices are high and recharge the battery during off-peak hours when the price per electricity unit is low, generating profit. Kindly rate the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
If the 'Vehicle-to-Grid' system is introduced I will highly consider the purchase of an electric vehicle in order to make profit.					
The 'Vehicle-to-Grid' system is viable only for those people who can recharge the vehicle at home during off-peak hours.					
The 'Vehicle-to-Grid' can only be successful if the system is introduced in the workplace where the vehicle is usually parked for a number of hours.					
I do not consider the 'Vehicle-to-Grid' system advantageous if it deteriorates the battery at a fast rate.					

28) Battery swapping involves the substitution of a depleted battery with a fully charged battery in battery swapping stations. Therefore, consumers purchase an electric vehicle without a battery and the battery is then leased from a battery swapping station operator. Please rate the following statements.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Battery swapping can motivate me to purchase an electric vehicle because it reduces the initial vehicle price.					
Battery swapping can help me to reduce range anxiety.					
Battery swapping solves any concerns related to battery deterioration.					
Battery swapping reduces operational costs, making electric vehicles more economically viable.					

Stated Choice Experiment - Hypothetical Scenarios

The following hypothetical scenarios do not fully reflect current vehicle prices and operational costs. However, when answering each choice task, imagine an attractive vehicle of your choice and apply the attributes in each choice task for the vehicle. It is important to consider each hypothetical scenario as if it reflects real life situations.

BEVs - Battery Electric Vehicles

Electric vehicles that operate utilising only the in-built battery which has to be charged.

HEVs - Hybrid Electric Vehicles

HEVs operate on both an internal combustion engine and an electric motor that uses energy stored in the battery which charges by the vehicle's braking system.

PHEVs - Plug-in Hybrid Electric Vehicles

PHEVs operate on both an internal combustion engine and an electric motor that uses energy stored in the battery. The battery is charged either by the braking system or by plugging to an electric charging point.

29) Hypothetical scenario 1: Choose the preferred vehicle option from the following hypothetical scenario.

	Petrol vehicle	Diesel vehicle	Electric Vehicle
Purchase price	€20,000	€22,000	€36,000
Road licence	€100	€125	€0
Fuel / charging cost per 100km	€10	€8	€2
Battery replacement price	€90	€100	€5,000

30) Hypothetical scenario 2: Choose the preferred vehicle option from the following hypothetical scenario.

	Petrol vehicle	Diesel vehicle	Electric Vehicle
Purchase price	€22,000	€23,000	€24,000
Road licence	€111	€121	€90
Fuel / charging cost per 100km	€11	€9	€3
Battery replacement price	€95	€105	€5,500

31) Hypothetical scenario 3: Choose the preferred vehicle option from the following hypothetical scenario.

	Petrol vehicle	Diesel vehicle	Electric Vehicle
Purchase price	€30,000	€35,000	€23,000
Road licence	€550	€560	€10
Fuel / charging cost per 100km	€12	€10	€4
Battery replacement price	€100	€101	€5,300

32) Hypothetical scenario 4: Choose the preferred vehicle option from the following hypothetical scenario.

	Petrol vehicle	**Diesel vehicle**	**Electric Vehicle**
Purchase price	€21,000	€23,000	€25,000
Road licence	€103	€102	€101
Fuel / charging cost per 100km	€20	€16	€4
Battery replacement price	€102	€103	€5,100

33) Hypothetical scenario 5: Choose the preferred vehicle option from the following hypothetical scenario.

	Petrol vehicle	**Diesel vehicle**	**Electric Vehicle**
Purchase price	€20,000	€22,000	€23,000
Road licence	€113	€114	€100
Fuel / charging cost per 100km	€15	€13	€12
Battery replacement price	€120	€130	€150

34) Hypothetical scenario 6: Choose the preferred vehicle option from the following hypothetical scenario.

	Petrol vehicle	Diesel vehicle	Electric Vehicle
Purchase price	€20,000	€22,000	€35,000
Road licence	€125	€126	€120
Fuel / charging cost per 100km	€14	€12	€11
Battery replacement price	€125	€135	€140

35) If you intend to buy your first or another electric vehicle, which of the following options will you choose?
(* the grants in the table do not fully reflect current situation)

		Vehicle price	Subsidy	Final price
A.	**Brand new BEV**	€35,000	Benefit from €11,000 + €1,000 if scrapping an internal combustion engine vehicle which is at least 10 years old.	€23,000
B.	**Brand new PHEV**	€35,000	Benefit from €11,000 + €1,000 if scrapping an internal combustion engine vehicle which is at least 10 years old.	€23,000
C.	**Brand new BEV**	€35,000	Benefit from €11,000 but keep or sell your 10+ year old internal combustion engine vehicle.	€24,000
D.	**Brand new PHEV**	€35,000	Benefit from €11,000 but keep or sell your 10+ year old internal combustion engine vehicle.	€24,000
E.	**Brand new HEV**	€22,000	No subsidy	€22,000

36) If you own a battery electric vehicle (BEV) which runs exclusively on its internal battery, which one of the following three charging options will you choose to charge your vehicle on a regular basis?

	Slow home AC charging	**Medium AC charging pillars**	**Fast DC charging pillars**
Price	Off peak: €0.1298/unit On peak: €0.1485/unit	Off peak: €0.1698/unit On peak: €0.1885/unit	Off peak: €0.1798/unit On Peak: €0.1985/unit
Time	12 hours	6 hours	30 minutes
Battery degradation	Minimal degradation	Moderate degradation	Fast degradation

37) Choose the preferred vehicle option taking into account range, charging time and carbon dioxide emission reduction.

	Option 1: BEV	**Option 2: PHEV**	**Option 3: HEV**	**Option 4: Internal combustion engine vehicle**
Vehicle price	€35,000	€35,000	€22,000	€22,000
Driving Range on full charge / fuel tank	300km	300km	300km	300km
Charging / Refuelling time	6 hours	6 hours	5-10 minutes	5-10 minutes
Carbon Dioxide (CO_2) emissions	0%	50%	75%	100%

38) Do you have any suggestions which can be implemented in order to increase electric vehicle adoption among Maltese consumer? ________________________________

Appendix B: Crosstabulation of different socio-demographic variables and electric vehicle ownership

			Electric Vehicle ownership (HEV, PHEV, BEV) Yes	No	Total
Age	18 - 28 years	Count	8	31	39
		% within Age	20.51%	79.49%	100.00%
	29 - 38 years	Count	9	68	77
		% within Age	11.69%	88.31%	100.00%
	39 - 48 years	Count	19	65	84
		% within Age	22.62%	77.38%	100.00%
	49 - 58 years	Count	9	54	63
		% within Age	14.29%	85.71%	100.00%
	59 - 65 years	Count	12	12	24
		% within Age	50.00%	50.00%	100.00%
	65+ years	Count	9	21	30
		% within Age	30.00%	70.00%	100.00%
Total		Count	66	251	317
		% within Age	20.82%	79.18%	100.00%

Table B1: Crosstabulation of age and electric vehicle ownership.

Chi-Square Test	Value	df	p-value
Pearson Chi-Square	19.623	5	.001

Table B2: Chi-Square test of age and electric vehicle ownership.

			Electric Vehicle ownership (HEV, PHEV, BEV)		
			Yes	No	Total
Gender	Male	Count	46	142	188
		Percentage	24.47%	75.53%	100.0%
	Female	Count	20	109	129
		Percentage	15.50%	84.50%	100.0%
Total		Count	66	251	317
		Percentage	20.82%	79.18%	100.0%

Table B3: Crosstabulation of gender and electric vehicle ownership.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	3.729	1	.053

Table B4: Chi-Square test of gender and electric vehicle ownership.

			Electric Vehicle ownership (HEV, PHEV, BEV)		
			Yes	No	Total
Marital status	Single	Count	13	94	107
		% within Martial status	12.15%	87.85%	100.00%
	Married	Count	48	140	188
		% within Martial status	25.53%	74.47%	100.00%
	Widowed	Count	1	5	6
		% within Martial status	16.67%	83.33%	100.00%
	Separated	Count	3	12	15
		% within Martial status	20.00%	80.00%	100.00%
	Divorced	Count	1	0	1
		% within Martial status	100.00%	0.00%	100.00%
Total		Count	66	251	317
		% within Martial status	20.82%	79.18%	100.00%

Table B5: Crosstabulation of marital status and electric vehicle ownership.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	11.283	4	.024

Table B6: Chi-Square test of marital status and electric vehicle ownership.

			Electric Vehicle ownership (HEV, PHEV, BEV)		
			Yes	No	Total
Education level	Secondary education	Count	2	21	23
		% within Education level	8.70%	91.30%	100.00%
	Sixth Form education	Count	12	45	57
		% within Education level	21.05%	78.95%	100.00%
	Undergraduate qualification (certificate, diploma, Bachelor's degree)	Count	27	108	135
		% within Education level	20.00%	80.00%	100.00%
	Postgraduate qualification (certificate, diploma, Master degree, Ph.D)	Count	25	77	102
		% within Education level	24.51%	75.49%	100.00%
Total		Count	66	251	317
		% within Education level	20.82%	79.18%	100.00%

Table B7: Crosstabulation of education level and electric vehicle ownership.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	2.950	3	.399

Table B8: Chi-Square test of education level and electric vehicle ownership.

			Electric Vehicle ownership (HEV, PHEV, BEV)		
			Yes	No	Total
Employment Status	Employed	Count	50	212	262
		% within Employment Status	19.1%	80.9%	100.0%
	Unemployed	Count	0	6	6
		% within Employment Status	0.0%	100.0%	100.0%
	Retired	Count	11	20	31
		% within Employment Status	35.5%	64.5%	100.0%
	Student and also a part-time employee	Count	2	6	8
		% within Employment Status	25.0%	75.0%	100.0%
	Student performing no part-time jobs	Count	1	4	5
		% within Employment Status	20.0%	80.0%	100.0%
	Self-Employed	Count	2	3	5
		% within Employment Status	40.0%	60.0%	100.0%
Total		Count	66	251	317
		% within Employment Status	20.8%	79.2%	100.0%

Table B9: Crosstabulation of employment status and electric vehicle ownership.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	7.303	5	.199

Table B10: Chi-Square test of employment status and electric vehicle ownership.

			Electric Vehicle ownership (HEV, PHEV, BEV)		
			Yes	No	Total
Location of regular residence by district	Southern Harbour District	Count	7	78	85
		% within Location of regular residence by district	8.24%	91.76%	100.00%
	Northern Harbour District	Count	9	37	46
		% within Location of regular residence by district	19.57%	80.43%	100.00%
	South-Eastern District	Count	19	60	79
		% within Location of regular residence by district	24.05%	75.95%	100.00%
	Western District	Count	12	25	37
		% within Location of regular residence by district	32.43%	67.57%	100.00%
	Northern District	Count	16	35	51
		% within Location of regular residence by district	31.37%	68.63%	100.00%
	Gozo and Comino District	Count	3	16	19
		% within Location of regular residence by district	15.79%	84.21%	100.00%
Total		Count	66	251	317
		% within Location of regular residence by district	20.82%	79.18%	100.00%

Table B11: Crosstabulation of regular residence by district and electric vehicle ownership.

Chi-Square Tests

	Value	df	p-value
Pearson Chi-Square	15.473	5	.009

Table B12: Chi-Square test of regular residence by district and electric vehicle ownership.

			Number of electric vehicles (HEV, PHEV, BEV) owned by the household				
			None	One	Two	Three	Total
Location of regular residence by district	Southern Harbour District	Count	98	9	0	0	107
		% within Location of regular residence by district	91.59%	8.41%	0.00%	0.00%	100.0%
	Northern Harbour District	Count	41	11	2	0	54
		% within Location of regular residence by district	75.93%	20.37%	3.70%	0.00%	100.00%
	South-Eastern District	Count	73	28	0	0	101
		% within Location of regular residence by district	72.28%	27.72%	0.00%	0.00%	100.00%
	Western District	Count	35	12	1	0	48
		% within Location of regular residence by district	72.92%	25.00%	2.08%	0.00%	100.00%
	Northern District	Count	42	15	2	1	60
		% within Location of regular residence by district	70.00%	25.00%	3.33%	1.67%	100.00%
	Gozo and Comino District	Count	18	3	0	0	21
		% within Location of regular residence by district	85.71%	14.29%	0.00%	0.00%	100.00%
Total		Count	307	78	5	1	391
		% within Location of regular residence by district	78.52%	19.95%	1.28%	0.26%	100.00%

Table B13: Crosstabulation of regular residence by district and number of electric vehicles owned by the household.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	28.835	15	.017

Table B14: Chi-Square test of regular residence by district and number of electric vehicles owned by the household.

			Electric Vehicle ownership (HEV, PHEV, BEV) Yes	No	Total
Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	less than €10,000	Count	3	78	81
		% within Vehicle owners: Usual budget when buying a vehicle, exclhuding part exchange	3.70%	96.30%	100.00%
	between €10,001 - €20,000	Count	13	129	142
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	9.15%	90.85%	100.00%
	between €20,001 - €30,000	Count	30	39	69
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	43.48%	56.52%	100.00%
	between €30,001 - €40,000	Count	16	1	17
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	94.12%	5.88%	100.00%
	More than €40,000	Count	4	4	8
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	50.00%	50.00%	100.00%
Total		Count	66	251	317
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	20.82%	79.18%	100.00%

Table B15: Crosstabulation of usual budget when buying a vehicle and electric vehicle ownership.

Chi-Square Tests	Value	df	p-value
Pearson Chi-Square	107.139	4	<.001

Table B16: Chi-Square test of usual budget when buying a vehicle and electric vehicle ownership.

			Number of electric vehicles (HEV, PHEV, BEV) owned by the household				
			None	One	Two	Three	Total
Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	less than €10,000	Count	79	2	0	0	81
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	97.53%	2.47%	0.00%	0.00%	100.00%
	between €10,001 - €20,000	Count	126	15	1	0	142
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	88.73%	10.56%	0.70%	0.00%	100.00%
	between €20,001 - €30,000	Count	33	32	3	1	69
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	47.83%	46.38%	4.35%	1.45%	100.00%
	between €30,001 - €40,000	Count	1	16	0	0	17
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	5.88%	94.12%	0.00%	0.00%	100.00%
	More than €40,000	Count	4	3	1	0	8
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	50.00%	37.50%	12.50 %	0.00%	100.00%
Total		Count	243	68	5	1	317
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	76.66%	21.45%	1.58%	0.32%	100.00%

Table B17: Crosstabulation of usual budget when buying a vehicle and number of electric vehicles owned by the household.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	126.118	12	<.001

Table B18: Chi-Square test of usual budget when buying a vehicle and number of electric vehicles owned by the household.

			Electric Vehicle ownership (HEV, PHEV, BEV)		
			Yes	No	Total
Residence type	House with garage and access to electricity	Count	37	97	134
		% within Residence type	27.61%	72.39%	100.00 %
	House with garage with no access to electricity	Count	1	5	6
		% within Residence type	16.67%	83.33%	100.00 %
	House without a garage	Count	4	38	42
		% within Residence type	9.52%	90.48%	100.00 %
	Maisonette / Apartment with garage and access to electricity	Count	19	51	70
		% within Residence type	27.14%	72.86%	100.00 %
	Maisonette / Apartment with garage and no access to electricity	Count	1	19	20
		% within Residence type	5.00%	95.00%	100.00 %
	Maisonette / Apartment without a garage	Count	4	41	45
		% within Residence type	8.89%	91.11%	100.00 %
Total		Count	66	251	317
		% within Residence type	20.82%	79.18%	100.00 %

Table B19: Crosstabulation of residence type and electric vehicle ownership.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	15.683	5	.008

Table B20: Chi-Square test of residence type and electric vehicle ownership.

			Electric Vehicle ownership (HEV, PHEV, BEV)		
			Yes	No	Total
Total number of vehicles owned by the household	None	Count	0	1	1
		% within Total number of vehicles owned by the household	0.00%	100.00%	100.00%
	One	Count	18	56	74
		% within Total number of vehicles owned by the household	24.32%	75.68%	100.00%
	Two	Count	24	110	134
		% within Total number of vehicles owned by the household	17.91%	82.09%	100.00%
	Three	Count	14	52	66
		% within Total number of vehicles owned by the household	21.21%	78.79%	100.00%
	Four	Count	7	29	36
		% within Total number of vehicles owned by the household	19.44%	80.56%	100.00%
	More than four	Count	3	3	6
		% within Total number of vehicles owned by the household	50.00%	50.00%	100.00%
Total		Count	66	251	317
		% within Total number of vehicles owned by the household	20.82%	79.18%	100.00%

Table B21: Crosstabulation of the total number of vehicles owned by the household and electric vehicle ownership.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	4.649	5	.460

Table B22: Chi-Square test of the total number of vehicles owned by the household and electric vehicle ownership.

			Charging preference considering charging time and battery degradation			
			Slow home AC charging	Medium AC charging pillars	Fast DC charging pillars	Total
Residence type	House with garage and access to electricity	Count	127	18	18	163
		% within Residence type	77.91%	11.04%	11.04%	100.00%
	House with garage with no access to electricity	Count	5	3	0	8
		% within Residence type	62.50%	37.50%	0.00%	100.00%
	House without a garage	Count	30	19	9	58
		% within Residence type	51.72%	32.76%	15.52%	100.00%
	Maisonette / Apartment with garage and access to electricity	Count	56	21	3	80
		% within Residence type	70.00%	26.25%	3.75%	100.00%
	Maisonette / Apartment with garage and no access to electricity	Count	17	8	1	26
		% within Residence type	65.38%	30.77%	3.85%	100.00%
	Maisonette / Apartment without a garage	Count	32	13	11	56
		% within Residence type	57.14%	23.21%	19.64%	100.00%
Total		Count	267	82	42	391
		% within Residence type	68.29%	20.97%	10.74%	100.00%

Table B23: Crosstabulation of residence type and charging preference.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	31.627	10	<.001

Table B24: Chi-Square test of residence type and charging preference.

			Charging preference considering charging time and battery degradation			
			Slow home AC charging	Medium AC charging pillars	Fast DC charging pillars	Total
Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	less than €10,000	Count	44	22	15	81
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	54.32%	27.16%	18.52%	100.00%
	between €10,001 - €20,000	Count	97	32	13	142
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	68.31%	22.54%	9.15%	100.00%
	between €20,001 - €30,000	Count	57	6	6	69
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	82.61%	8.70%	8.70%	100.00%
	between €30,001 - €40,000	Count	15	2	0	17
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	88.24%	11.76%	0.00%	100.00%
	More than €40,000	Count	6	1	1	8
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	75.00%	12.50%	12.50%	100.00%
Total		Count	219	63	35	317
		% within Vehicle owners: Usual budget when buying a vehicle, excluding part exchange	69.09%	19.87%	11.04%	100.00%

Table B25: Crosstabulation of usual budget when buying a vehicle and charging preference.

Chi-Square Tests			
	Value	df	p-value
Pearson Chi-Square	19.923	8	.011

Table B26: Chi-Square test of usual budget when buying a vehicle and charging preference.

Appendix C: Evaluation of the consumer attitude, perceptions and knowledge towards electric vehicle adoption using Likert Scales

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Running an electric vehicle emits less carbon dioxide when compared to internal combustion engine vehicles.	Count	3	10	30	151	197	391
	Percentage	0.77	2.56	7.67	38.62	50.38	100
I prefer BEVs over PHEVs and HEVs because BEVs release no tailpipe emissions, therefore are more environmentally friendly.	Count	7	35	107	150	92	391
	Percentage	1.79	8.95	27.37	38.36	25.53	100
The emissions released during the production of electric vehicles tends to be higher when compared to the emissions released during the production of internal combustion engine vehicles.	Count	14	27	259	61	30	391
	Percentage	3.58	6.91	66.24	15.60	7.67	100
Charging an electric vehicle may contribute to air pollution.	Count	15	31	221	88	36	391
	Percentage	3.84	7.93	56.52	22.51	9.21	100

Table C1: The consumers' awareness on the level of emissions related to the production, running and charging of electric vehicles.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
The decision of adopting an electric vehicle or otherwise is influenced by the opinion of relatives and friends.	Count	181	108	43	53	6	391
	Percentage	46.29	27.62	11.00	13.55	1.53	100
Only an increase in electric vehicle adoption among the general public reassures me on the reliability of electric vehicles.	Count	49	111	55	157	19	391
	Percentage	12.53	28.39	14.07	40.15	4.86	100
Driving an electric vehicle makes me proud since it expresses environmental consciousness.	Count	45	97	72	130	47	391
	Percentage	11.51	24.81	18.41	33.25	12.02	100
Free parking in highly congested areas, and a subsidised Gozo Channel ferry fee can motivate me to adopt an electric vehicle even though public opinion is against the adoption of such vehicles.	Count	18	49	71	202	51	391
	Percentage	4.60	12.53	18.16	51.66	13.04	100

Table C2: The role of social influence in electric vehicle adoption.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
I consider buying a PHEV / BEV as my next car to save fuel costs.	Count	18	43	65	134	131	391
	Percentage	4.60	11.00	16.62	34.27	33.50	100
Both HEVs and PHEVs incur higher maintenance costs when compared to BEVs because both vehicles have an internal combustion engine, an electric motor and a battery while BEVs are not equipped with an internal combustion engine.	Count	10	17	81	178	105	391
	Percentage	2.56	4.35	20.72	45.52	26.85	100
Both HEVs and PHEVs are more reliable than BEVs since they can run an internal combustion engine.	Count	19	35	79	127	131	391
	Percentage	4.86	8.95	20.20	32.48	33.50	100
I prefer a HEVs over BEVs and PHEVs because HEVs have a lower market price.	Count	28	83	99	140	41	391
	Percentage	7.16	21.23	25.32	35.81	10.49	100

Table C3: The consumers' perception towards the three types of electric vehicles (HEV, PHEV, BEV) on the market.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
I consider the purchase of electric vehicles only because they are financially subsidised.	Count	13	63	56	87	172	391
	Percentage	3.32	16.11	14.32	22.25	43.99	100
Although electric vehicles are subsidised by the government, I still consider such vehicles unaffordable.	Count	8	37	44	135	167	391
	Percentage	2.05	9.46	11.25	34.53	42.71	100
I am concerned that electric vehicles are subject to a higher value depreciation when compared to internal combustion engine vehicles due to continuous developments in technology.	Count	4	26	79	239	43	391
	Percentage	1.02	6.65	20.20	61.13	11.00	100
Informative campaigns in the Maltese Island related to the electric vehicle total cost of ownership is still limited.	Count	5	5	47	102	232	391
	Percentage	1.28	1.28	12.02	26.09	58.34	100

Table C4: The consumers' perception towards the price and operational cost of electric vehicles.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Battery swapping can motivate me to purchase an electric vehicle because it reduces the initial vehicle price.	Count	18	29	85	88	171	391
	Percentage	4.60	7.42	21.74	22.51	43.73	100
Battery swapping can help me to reduce range anxiety.	Count	19	40	83	163	86	391
	Percentage	4.86	10.23	21.23	41.69	21.99	100
Battery swapping solves any concerns related to battery deterioration.	Count	11	38	72	202	68	391
	Percentage	2.81	9.72	18.41	51.66	17.39	100
Battery swapping reduces operational costs, making electric vehicles more economically viable.	Count	14	33	75	89	180	391
	Percentage	3.58	8.44	19.18	22.76	46.04	100

Table C5: Battery swapping as an opportunity to increase electric vehicle adoption.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
I consider the purchase of a second-hand electric vehicle because it is more affordable.	Count	33	57	54	167	80	391
	Percentage	8.44	14.58	13.81	42.71	20.46	100
I consider the purchase of a second-hand HEV and not a second-hand PHEV / BEV because HEVs are the most common second-hand electric vehicles in stock.	Count	36	90	84	148	33	391
	Percentage	9.21	23.02	21.48	37.85	8.44	100
I prefer to purchase second-hand vehicles but I am concerned about the level of battery deterioration in a second-hand electric vehicle.	Count	18	34	52	201	86	391
	Percentage	4.60	8.70	13.30	51.41	21.99	100
I prefer to buy a second-hand HEV over a second-hand BEV / PHEV because I am concerned about the high battery replacement cost of BEV / PHEV.	Count	25	72	69	146	79	391
	Percentage	6.39	18.41	17.65	37.34	20.20	100

Table C6: The consumers' perception towards the price and operational cost of second-hand electric vehicles.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
Currently, individuals that buy a BEV can benefit from a grant of €11,000 and an extra €1,000 when scrapping an internal combustion engine vehicle which is 10 years and older.	Count	6	7	51	132	195	391
	Percentage	1.53	1.79	13.04	33.76	49.87	100
BEV and PHEV adopters are exempted from registration tax and from paying road licence for the first 5 years. From the sixth year onwards the licence fee amounts to €10.	Count	15	23	59	119	175	391
	Percentage	3.84	5.88	15.09	30.43	44.76	100
Electric vehicle owners do not pay any fee when accessing areas in Valletta controlled by the Controlled Vehicular Access (CVA) system.	Count	26	29	157	76	103	391
	Percentage	6.65	7.72	40.15	19.44	26.34	100
A total of 3 government solar charging stations can be utilised to charge an electric vehicle for free.	Count	25	33	214	46	73	391
	Percentage	6.39	8.44	54.73	11.76	18.67	100

Table C7: The consumers' awareness economic incentives to promote electric vehicle adoption.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
I am concerned that the electric vehicle battery gets depleted before reaching destination.	Count	34	75	56	111	115	391
	Percentage	8.70	19.18	14.32	28.39	29.41	100
Electric vehicles are more complicated to drive when compared to conventional vehicles.	Count	97	82	183	23	6	391
	Percentage	24.81	20.97	46.80	5.88	1.53	100
I am concerned about where to service an electric vehicle when the need arises.	Count	21	67	47	120	136	391
	Percentage	5.37	17.14	12.02	30.69	34.78	100
I am concerned about the safety of electric vehicles such as fires or accidents due to low operational sound.	Count	27	66	191	72	35	391
	Percentage	6.91	16.88	48.85	18.41	8.95	100

Table C8: The consumers' non-economic concerns towards the adoption of electric vehicles.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
The need to plug-in the vehicle for charging purposes makes battery electric vehicles very unpractical for use in everyday life.	Count	36	70	43	98	144	391
	Percentage	9.21	17.90	11.00	25.06	36.83	100
I am discouraged by the time taken to charge the battery of the electric vehicle (PHEV / BEV).	Count	35	72	42	148	94	391
	Percentage	8.95	18.41	10.74	37.85	24.04	100
I think there are sufficient public charging points around the Maltese Islands.	Count	234	79	44	26	8	391
	Percentage	59.85	20.20	11.25	6.65	2.05	100
Home charging or having a charging point close to my residence is a determinant variable when deciding on whether to buy an electric vehicle or not.	Count	4	13	29	115	230	391
	Percentage	1.02	3.32	7.42	29.41	58.82	100

Table C9: Electric vehicles charging as a barrier towards their adoption.

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Total
If the 'Vehicle-to-Grid' system is introduced I will highly consider the purchase of an electric vehicle in order to make profit.	Count	94	120	105	52	20	391
	Percentage	24.04	30.69	26.85	13.30	5.12	100
The 'Vehicle-to-Grid' system is viable only for those people who can recharge the vehicle at home during off-peak hours.	Count	6	14	65	172	134	391
	Percentage	1.53	3.58	16.62	43.99	34.27	100
The 'Vehicle-to-Grid' can only be successful if the system is introduced in the workplace where the vehicle is usually parked for a number of hours.	Count	7	12	66	137	169	391
	Percentage	1.79	3.07	16.88	35.04	43.22	100
I do not consider the 'Vehicle-to-Grid' system advantageous if it deteriorates the battery at a fast rate.	Count	6	20	68	232	65	391
	Percentage	1.53	5.12	17.39	59.34	16.62	100

Table C10: The 'Vehicle-to-Grid' system as an opportunity to increase electric vehicle adoption.