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Electric or not? Factors affecting Greek Drivers' Preference when Purchasing a New Vehicle

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Abstract

This study deployed a stated-preference questionnaire to understand the preferences of citizens in Athens, Greece, towards electric and hybrid-electric vehicles. Specifically, it was aimed to see whether and under which conditions they are willing to purchase a greener vehicle type. The analysis of the questionnaire survey data showed that citizens are in favor of electric and hybrid-electric vehicles provided that there are monetary incentives and provision of charging facilities.

Keywords: electric vehicles; hybrid vehicles; emissions; stated-preference.

1. Introduction

Transport electrification is one means to reduce greenhouse gases (GHG) and in turn, achieve ambitious climate change goals. At the local level, the massive presence of low- and zero-emission vehicles has the potential improve public health by improving air quality and reducing noise levels (IEA, 2016). The human toll for poor air quality is worse than for road traffic accidents, making it the number one environmental cause of premature death in the EU, with over 390 000 premature deaths every year. In Europe and around the globe, governments have implemented a set of measures and policies with the objective to accelerate the adoption of electric or hybrid-electric personal vehicles. These measures include for example, monetary incentives for purchasing electric or hybrid-electric vehicles, but also the placement of chargers in more and more locations both in urban and rural settings. Research at the international level, has identified that barriers such as high purchase costs, small range, and dependence on charging infrastructure are limiting the massive adoption of those vehicles (Axsen et al., 2010; Egbue & Long, 2012; Leiby & Rubin, 2004)

Greece moves along the same direction and aims through monetary incentives and the provision of an increasing network of charging facilities to encourage citizens to purchase electric or hybrid-electric vehicles. According to 2020 statistics, the EU averages for the share of batter electric, plug-in, and hybrid-electric passenger vehicles were

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0.5%, 0.6%, and 1.2% respectively (ACEA, 2022). The respective values for Greece are rather low: 0%, 0% and 0.7% (ACEA, 2022). Low- or zero-emission vehicles in Greek cities would be of high importance as many cities and especially Athens experience high air quality and noise pollution levels.

In this context, this research aims to explore the attitudes of drivers in the capital of Greece, Athens, towards the purchase of electric or hybrid-electric vehicles. While it is well-known that there is a trade-off between the ownership and operating when it comes to electric and hybrid electric vehicles (Palmer et al., 2018), up to date it is not fully clear which factors are critical and so, can play a central role in the mass adoption of personal low- or zero-emission vehicles in countries similar to Greece. Secondarily, it is explored whether citizens in Athens metropolitan area find the monetary incentives on the purchase of electric vehicles appealing or not. The outcome of this research can be used by policy makers, local authorities, and other relevant stakeholders (e.g., professionals in the automotive market) to introduce appropriate measures for the Greek context to increase the electric vehicle adoption rate.

This research considers three types of vehicles:

1. battery electric vehicles or simply noted as electric vehicles(EVs): vehicles that run exclusively on electricity using an electric motor and an on-board battery which is charged by plugging it into a charging point (IEA, 2013).
2. hybrid electric vehicles (HEVs): vehicles that combine a conventional internal combustion engine with an electric motor. For this study, this category includes both vehicles that can be charged (i.e., plug-in hybrid) and those that charge their batteries from capturing energy (e.g., braking energy).
3. internal combustion engine vehicles (ICEVs): vehicles that use an internal combustion engine, typically fed with fossil fuels such as petrol or diesel.

Section 2 presents the relevant literature is factors affecting the decision of consumers to purchase electric or hybrid electric vehicles. Section 3 describes the methodology and section 4 presents the findings of this work. Finally, conclusions and future extensions are discussed in the last section.

2. Background

Current literature on transportation electrification has focused on understanding which population segments are more likely to be in favor of electric and hybrid electric vehicles and/or which part of the population is more likely to actually purchase electric or hybrid vehicles. Additionally, researchers have also explored which policies are effective in triggering people to purchase electric or hybrid electric vehicles. These questions have been approached using questionnaire survey data or vehicle sales data.

Several studies have found that the general public is positive towards low- and zero-emission personal vehicles and are in favor of their massive adoption (Bienias et al., 2020; Valeri & Danielis, 2015). However, this trend is not depicted in current adoption rates, as in Europe for example the share of electric and hybrid electric vehicles is very small (ACEA, 2022).

Policy measures such as financial incentives, the placement of public charging infrastructure, the provision of parking or access to bus lanes have been found to increase electric vehicle share (Langbroek et al., 2016; Sierzchula et al., 2014; Egne´r & Trosvik, 2018; Danielis et al., 2020). Among those policies it has been shown that the presence of public charging infrastructure as well as the monetary incentives are the most effective ones. This is reasonable as electric and hybrid electric vehicles are more expensive and so, citizens need a financial assistance to complete the purchase and then, in order to operate their vehicle it is critical to ensure that it can be charged (almost) at any time. While those measures have been found effective, it is also advised to adjust them at the local conditions to maximize their impact (Egne´r & Trosvik, 2018).

Research on the characteristics of the early adopters have shown that they are more likely to live in urbanized areas and have university degree (Mukherjee & Ryan, 2020; Egne´r & Trosvik, 2018). In the literature, there have not been found associations with other socioeconomic characteristics and preference towards electric vehicles. However, some additional personal characteristics play a role in purchasing an electric vehicle. People more familiarized with technology and eager to test new technologies are more likely to purchase electric vehicles (Resvani et al., 2015)

while another study found that ease and pleasure of driving are related to choosing an electric vehicle over an ICEV (Tchetchik et al., 2020).

3. Methodology

This research used a stated preference approach to explore (a) the attitudes of citizens in Athens, Greece, metropolitan area towards the potential to purchase an electric or hybrid electric vehicle and (b) whether and how they are affected by the Greek government monetary incentives. A questionnaire survey was developed to collect data to answer the aforementioned questions. The following paragraphs explain the structure of the questionnaire survey as well as the mathematical models that were used for the analysis.

3.1. Questionnaire survey structure

The questionnaire survey consisted of 34 questions organized in four sections. The very first question asked the participant to provide a zip code to ensure they are residents of Athens metropolitan area. The second question aimed at filtering out participants that did not aim to purchase a vehicle in a horizon of ten years.

Participants that were filtered out from the questionnaire survey, answered a set of questions related to their travel behavior, driving experience, and lastly their familiarity with new transport technologies and electro-mobility. After this section, participants started the second section, answering questions about their perception and attitudes related to personal electric vehicles, e.g., "Based on your opinion, what are the most important advantages of electric vehicles?". The third section of the questionnaire survey is essentially the core part of it. Participants were asked to state their preference in ten scenarios. Specifically, they were asked to choose among an electric, hybrid and conventional vehicles based on:

1. vehicle purchase cost in €, ranging from:
    - 15-25K for conventional vehicles
    - 20-30K for hybrid-electric vehicles
    - 20-35K for electric vehicles
2. fuel cost (in €) to travel a distance of 500km, ranging from:
    - 55-60€, for conventional vehicles
    - 35-40€, for hybrid-electric vehicles
    - 10-15€, for electric vehicles
3. ease of refueling/recharging: qualitative variable with three levels, i.e., low, medium, high.

The fourth section of the questionnaire collected participants' demographic and socioeconomic characteristics.

3.2. Modeling

The utility of a product (or service), e.g., personal vehicle, depends on the attributes of the product (Lancaster , 1966). Essentially, when choosing between different products their attributes are compared and the attribute levels of those attributes are crucial when making a choice between different alternatives. This is the base of the Random Utility Theory according to which decision makers are assumed to be rational and try to maximize their utility when making choices. Decision makers choose those alternatives that maximize their utility. In this study, the Random Utility Theory framework is adopted to analyze the participants' choice of the vehicle type, i.e., choosing among an electric, hybrid electric or internal combustion engine vehicle.

Based on the utility maximization framework, the utility of an alternative i (U_i) consists of a systematic part V_i and an error term ϵ, where the systematic part consists of (a) a vector of attributes a (e.g., cost, time) with attribute values

X_{ia} for a given alternative i, and (b) their marginal effect on utility β_{ia} and an Alternative Specific Constant ASC that captures systematic but non-explained variability in the data:

$$U_i = V_i + \epsilon \quad (1)$$

Where V_i is given by:

$$V_i = \beta' X_i' + ASC_i \quad (2)$$

A multinomial logit model (MNL-model) was developed to quantify participants' choice related to the vehicle type, as a function of vehicle purchase cost, fuel cost to travel a distance of 500km, ease of refueling/recharging and a set of independent variables that express participants' characteristics using data from the first, second and fourth section of the questionnaire survey. For each alternative vehicle type, a utility function can be specified from the developed MNL-model. Using the utility functions for all three alternatives, one can then estimate the probability that an individual selects one of three alternative vehicle types.

In addition to the MNL-model, a binary logistic regression model was developed to model participants' response to the question: "Do you intend to purchase an electric car based on the current governmental incentives?". Answers to the questions of first, second and fourth sections were considered as potential independent variables of the binary logistic regression model.

4. Results and discussion

This section presents the findings from the analysis as well as a discussion on the findings. In the first subsection, we present statistics related to the participants' characteristics while the second and third subsections present and discuss the developed models.

4.1. Descriptive statistics for the sample

The questionnaire survey was initiated by 313 people. However, some of the recorded questionnaires were incomplete and had to be withdrawn. In several others, the participants were not residents of Athens metropolitan area or they did not plan on purchasing a vehicle at any point in the coming ten years; therefore, they were not eligible for the questionnaire survey. In total, data from 243 participants were used for this research.

Slightly more men (54%) compared to women completed the questionnaire survey, while the majority of respondents were of young age. In particular, almost 75% of the participants were from 18 up to 35 years old, while only 2.5% of respondents was above 60 years old. To some extent, this age distribution is expected given that participants for this survey were detected through university channels.

Almost half of the respondents stated to have an average annual income up to 15,000 €, and 16.5% had an average annual income above 30,000 €. In their great majority, respondents have or close to get a university degree.

In the question: "Do you think that we are close to the wide adoption of electric vehicles?", 77% of the participants replied positively. At the same time though, 87.2% of them have never driven an electric or hybrid-electric vehicle. Three out of four participants are positive towards the purchase of an electric or hybrid-electric vehicle, taking into consideration the monetary incentives posed by the Greek government.

More than half of the participants stated that the advantages of electric vehicles are related to environmental aspects, reduced operating costs and zero traffic noise. For the case of Athens, more than 75% of the participants stated that the massive deployment of electric vehicles will be delayed due to lack of charging and supporting infrastructure, while other reasons are related to bureaucracy and taxation.

4.2. Modeling participants' willingness to purchase an electric or hybrid vehicle

Considering the current monetary incentives posed by the Greek government, participants were asked whether they would be willing to purchase an electric or hybrid-electric vehicle. This question aimed at assessing whether the public is positive the current incentives or not, and so, different ones should be introduced. The dependent variable is

binary in nature, as participants could reply “yes” or “no” to the above question. Following a backwards elimination process as well as with the objective to include independent variables from all sections of the questionnaire survey, the following appropriate set of independent variables was used to specify the final model (Table 1).

Table 1. Binary logistic regression model

Variable	Coefficient	Std Error	z-value	Pr(> |z|)
Intercept	1.4453	0.1899	7.612	< 0.000
TYPE_Ped	-0.3116	0.1146	-2.718	0.007
DR_TIME2	-0.3275	0.1145	-2.860	0.004
DR_TIME3	-0.8165	0.1910	-4.276	< 0.000
ADV_NOISE	0.9156	0.1046	8.756	< 0.000
DIS_CHARGETIME	-0.4893	0.1025	-4.775	< 0.000
RSN_INFRSTR	-0.3707	0.1231	-3.011	0.003
AGE	-0.4869	0.1236	-3.941	< 0.000
GENDER	1.1674	0.1108	10.541	< 0.000

The variable TYPE_Ped is binary and equal to one for cases that the participants has stated that their main means of transport is walking. DR_TIME2 and DR_TIME3 indicate that the participant stated to drive from one to three hours daily and more than three hours daily, respectively. ADV_NOISE is a binary variable and is equal to one when the participant has stated that considers zero noise pollution as an advantage of electric vehicles. DIS_CHARGETIME is a binary variable and is equal to one when the participant has stated that considers charging time as a disadvantage of electric vehicles. RSN_INFRSTR is a binary variable and is equal to one when the participant has stated that the absence of charging infrastructure delays the massive adoption of electric vehicles. AGE is the variable for participants age and was converted to binary to differentiate between younger (i.e., below 35 years old) and more senior participants. The variable is equal to one if the participant is older than 35 years old. GENDER is equal to one for male participants.

The variables selected for the final model are reasonable and statistically significant at the 95% confidence level or above that. Additionally, according to the Hosmer – Lemeshow goodness of fit test (Hosmer et al., 1988), chi-squared is equal to 5.745 (p-value = 0.274) indicates that the model fits the data.

Men are more likely to consider purchasing an electric or hybrid-electric vehicle, given the current government incentives, while the same holds for younger people. Potential advantages of electric and hybrid electric vehicles are positively associated with the willingness to purchase such a vehicle, while certain perceived disadvantages of those vehicles such as the increased charging time, reduce the participants’ willingness. Daily travel habits were also find associated with participants’ willingness to purchase electric or hybrid vehicles, which is reasonable. People that walk cannot either afford a car or have decided not to rely on cars, despite the car’s fuel type. At the same time, people that drive for more than one hour per day and the more someone drives above the one-hour threshold, the possibility of considering the purchase of an electric or a hybrid-electric vehicle reduces. It would be expected that people that drive a lot are more positive towards an electric vehicle, as there would be high cost-savings due to low operational costs compared to conventional vehicles. However, it seems that the specific sample, while it appears positive to electric/hybrid-electric vehicles (as stated in the questionnaire survey) are not yet convinced that this investment is appropriate.

4.3. Modeling participants’ choice with respect to vehicle type

This section presents the findings of the statistical analysis on participants’ choice of vehicle type, based on the data collected in section three of three questionnaire survey. Participants had to choose vehicle type, i.e., conventional electric, or hybrid-electric as a function of purchase cost, operating cost, and ease of fueling/charging.

A MNL-model was developed where the depended variable was the participant’s choice of vehicle type and the independent variables consisted of purchase cost (continuous variable) and ease of fueling/charging (ordinal variable) as well as a set of independent variables related to participants’ characteristics, habits, and preferences. The independent

variables were carefully selected not to be correlated, to be interpretable and meaningful, and improve the model's performance. Multiple trials were needed to conclude to the model specification presented in Table 2. It is noted that all variables are statistically significant at the 95% or 99% confidence levels. Additionally, it is noted that all variables, except of the purchase cost and ease of fueling/charging, are binary and are equal to one if the participant responded positively to the respective question.

Table 2. Multinomial logit model

Variable	Coefficient (HEV over ICEV[1])	Coefficient (EV over ICEV[2])
Intercept	-2.002	-1.915
Purchase cost	0.00008	0.00008
Ease of fueling/charging	0.601	0.601
Would you purchase a LPG[3] car	1.026	0.626
Would you purchase a CNG[4] car	2.006	1.616
Would you purchase an electric car	1.171	1.667
Would you purchase an hybrid-electric car	2.131	1.565
My car runs with diesel	1.135	1.100
My car is electric	2.997	n/a
Drive 1-3 hours per day	0.551	0.601
Never driven a EV/HEV	1.051	0.799
Disadvantage: High purchase cost	0.634	0.459
Advantage: Low maintenance cost	n/a	0.355
Time for electric vehicles	n/a	1.380
Willing to purchase EV/HEV	0.894	0.907
Annual income between 15,000-30,000.	n/a	-0.483
Annual income above 30,000.	-0.524	n/a
High school graduate	-0.511	n/a

[1]*Model for choosing a hybrid-electric vehicle (HEV) over an ICEV*
[2]*Model for choosing an electric vehicle (EV) over an ICEV*
[3] *LPG: Liquefied petroleum gas*
[4]*CNG: Compressed natural gas*

The findings show that participants chose hybrid-electric vehicles over an ICEV ones or electric vehicles over an ICEV despite the increase in the purchase cost and also, despite the fact that they consider this to be a disadvantage of hybrid electric and electric vehicles. This finding aligns with the findings of the binary logistic model showing that the majority of participants stated to be motivated by the current monetary incentives. The variable related to the ease of charging was positively associated with a greener vehicle type, suggesting that citizens value the effort of improving charging facilities for electric vehicles. Participants that have stated that they would be willing to purchase an alternative fuel vehicle such as LPG, CNG, hybrid-electric or electric cars as well as those that have stated to be willing to purchase a hybrid electric or electric vehicle considering the current monetary incentives, were found more likely to choose a hybrid-electric or an electric vehicle over an ICEV. This is an indication that a segment of the population is generally positive towards alternative fuel vehicles and so, under a proper policy framework they can be adopters of those vehicles. Participants that spend one to three hours driving per day are more likely to choose a hybrid electric or electric vehicle compared to ICEV. This finding is reasonable as this a viable range to drive without having range anxiety given the current charging network in Athens metropolitan area.

5. Conclusions

This research aimed to examine the attitudes of citizens in the Athens metropolitan area towards the purchase of electric or hybrid electric vehicles. A stated preference study was conducted using a questionnaire survey that was completed by almost 250 people. The results of the analysis suggest that study participants are positive towards low- and zero-emission vehicles and appreciate the current incentives.

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