Case Studies on Transport Policy 14 (2023) 101100

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

The influence of household characteristics on the purchase of clean cars. The case of Spain

José M. Arranz, Mercedes Burguillo *, Jeniffer Rubio

Department of Economics, University of Alcala, Spain

A R T I C L E I N F O

JEL CODES:
L38
Q40
Q58
R40

Keywords:
Demand for Clean Cars
Households
Decarbonization
Transportation Policies
Agenda 2030
Logit Model

A B S T R A C T

This paper determines the socioeconomic characteristics of Spanish households that use clean cars, with the aim of identifying how these characteristics influence the market penetration of these vehicles. This study is one of the few in the literature that analyses the characteristics of car users based on a broad sample of data, that is representative of 11.5 million households. The results allow us to identify socioeconomic challenges and opportunities regarding the goal of replacing combustion vehicles with clean vehicles. We estimate a logit model finding that high-income households are 29.3% more likely to use a clean vehicle than medium–low-income households. On the contrary, the gender and age of the household's main breadwinner present opportunities: if he is a male, it is more likely to use clean vehicles than if she is a woman, and households whose main breadwinner is over 55 or under 30 are more likely to use it. These results provide guidelines for a better design of public policies aimed at decarbonizing the transport sector through the replacement of conventional vehicles by clean ones. To do so it is important to consider the features of the social reality in which that objective is to be achieved.

1. Introduction

Transport plays an important role in climate change as it is one of the main sectors of the economy that affect air pollution and carbon emissions; furthermore, it is the only economic sector that has not reversed the trend in these emissions (White and Sintov, 2017). Thus, the transport sector is a focal point of the sustainability strategies of the European Commission (Hackbarth and Madlener, 2013). The point is that, within the global energy transition strategy of the European economy - for which each of the member countries has its own plans - the transport sector is the most sensitive sector, that is, the one that presents the greatest barriers to such a change. This is due to the characteristics of this sector, which is a diffuse sector that depends on the decisions of millions of drivers, continues to rely massively on the combustion of petroleum derivatives, and because clean technology still must improve in terms of price and autonomy. Specifically, the strategy to achieve an energy transition in the sector consists of replacing combustion engine vehicles with other types of less polluting vehicles such as electric, plug-in hybrid, and LPG (liquefied petroleum gas) vehicles. These types of vehicles have gained increasing interest, both among producers and consumers (Li et al., 2016). In addition, empirical evidence shows that these vehicles have the potential to reduce CO2 emissions and improve air quality, see for example Cox et al. (2018) for Switzerland and Knobloch et al. (2020) for 59 world regions.

From a public policy perspective, mechanisms have been implemented to encourage and facilitate the replacement of combustion vehicles with clean vehicles. Numerous scientific works also show that different types of public policies are effective in encouraging this replacement. Thus, there are studies that show that financial incentive policies can stimulate sales of clean vehicles and therefore promote their diffusion, see, for example, Münzel et al. (2019) and Wang et al. (2019). Other works have emphasized the positive effect of relief policies involving the value added tax (VAT) and other types of taxes linked to the purchase of a vehicle, or price subsidies, on the purchase of clean vehicles, see, for example, Potoglou and Kanaroglou (2007), Bjerkan et al. (2016) and Levay et al. (2017). There are also works that point out the importance of developing electric charging infrastructures to encourage the purchase of clean vehicles, see for example Fang et al. (2020).

In this context, Spain, which is the country on which this research is focused, has implemented ambitious regulations with measures and incentives to improve air quality in cities, promote the acquisition of

* Corresponding author.
E-mail addresses: josem.arranz@uah.es (J.M. Arranz), mercedes.burguillo@uah.es (M. Burguillo), jeniffernathaly.rubio@edu.ec (J. Rubio).

https://doi.org/10.1016/j.cstp.2023.101100
Received 27 May 2023; Received in revised form 4 September 2023; Accepted 12 October 2023
Available online 14 October 2023

clean vehicles, as well as to expand the installation of electricity recharging points. Among these policies, the subsidy model that the government carries out consisted in giving economic aid for the acquisition of clean vehicles. Additionally, with the aim of improving the infrastructure, there are programs that finance the costs of installing charging points. There are also tax incentives such as the exemption from the Motor Vehicle Registration Tax (IMVA) that is carried out based on the CO2 emissions of the vehicle. This incentive consists of not charging the tax for the cleanest vehicles and charging a higher rate for those vehicles with the highest CO2/km of emissions (Agencia Tributaria de España, AET, 2020). Another type of measure is the mandatory application of environmental labels on vehicles: these labels allow vehicles to be classified according to the levels of pollution that they emit and their environmental impact, and are mainly used to implement measures on circulation (allowing circulation at certain times, free parking, free access to central areas for clean vehicles, among others), especially in the largest cities where the greatest problems related to air quality are concentrated, such as the city centres of Madrid and Barcelona. On the other hand, for the renewal of the stock of vehicles, a subsidy is granted for the purchase of clean vehicles if they are replacing a car more than 10 years old, Higueras-Castillo et al. (2020). These policies are similar to the measures applied in other EU countries (European Commission, 2021).

In any case, as Higueras-Castillo et al. (2020) emphasize, the implemented measures had have a limited effect on the extension of the use of clean vehicles. Indeed, Spain is still in the initial phase of adopting clean vehicles compared to other neighbouring countries. The European market for clean cars is led by the Nordic countries, with Norway standing out, where clean vehicles represent 42 %, followed by the Netherlands, where 14 % of the total fleet is composed of clean vehicles (ACEA, 2020). However, in Spain, clean cars represented only 2.7 % of the total in 2020 (UNESPA, 2022). Hence, according to the Spanish energy transition plan, called the National Integrated Energy and Climate Plan 2021–2030 (Ministerio de Transición Energética y Reto Demográfico, 2020), the objective set for 2030 forecasts that clean vehicles in Spain will be 16 % of the total. With current data it is practically impossible for Spain to achieve that goal.

The case of Spain can also be illustrative for many countries. In fact, in many economies replacing combustion vehicles with more environmentally friendly alternatives is not easy; thus clean vehicles have not yet penetrated the market to a great extent (Hackbarth and Madlener, 2013). The acquisition of these cars is not increasing as expected despite the huge public subsidies to the demand and the technological advances of the industry (Ziegler and Abdelkafi, 2022). The point is that there are still many barriers for the general population to massively acquire this type of vehicle. Among the most commonly identified barriers are the low range of autonomy (Egbue and Long, 2012; Franke and Krems, 2013; Schneidereit et al., 2015), the high relative prices (Adepetu and Keshav,2017; Vassileva and Campillo, 2017; Bienias et al., 2020) and the lack of infrastructure, especially the paucity of recharging points (Egbue and Long, 2012). Regarding the last factor, in Spain in the second quarter of 2021, there were barely 11,847 recharging points, a figure that is far from the objective set for the year 2022 of having between 45,000 and 48,000 points available (ANFAC, 2021).

Therefore, despite the efforts of governments to stimulate purchases, there are still barriers linked to supply that make it difficult to replace combustion vehicles with clean vehicles (Egbue and Long, 2012) and (Higueras-Castillo et al., 2021). But, in addition, there are also barriers linked to demand. Therefore, it is very important to know and characterize well all the aspects of both supply and demand that may constitute barriers to the acquisition of clean vehicles. In this sense, it is crucial to understand, among other issues, what are the socioeconomic and demographic characteristics of the buyers of this type of car, because the literature has widely analysed the effects of the policy measures on the demand, however, the demand (the characteristics of car buyers) has also an effect on the policy implemented, and this has been scarcely treated by the literature.

Specifically, in this paper we are going to analyse the characteristics of Spanish households that have already purchased a clean vehicle in order to have a better understanding of the socioeconomic profile of those who, despite the existing supply barriers -high relative price, low autonomy, and scarcity of recharging points- have had a preference for buying a clean car. This will make it possible to characterize the socioeconomic and demographic factors of that demand in order to identify which socioeconomic and demographic characteristics favour and which disfavour buying a clean vehicle. So we are going to analyse how the demand has an effect on the policies implemented. Therefore, we are going to analyse to what extent, taking the case of Spain as an example, the current society of Western countries presents pros and cons to achieve the objectives of the 2030 Agenda linked to the transport sector. To that end, having a better understanding of the socioeconomic and demographic situation that explains the demand for clean vehicles is very important. This is something that has not been sufficiently analysed in the literature, which has mainly focused on studying supply issues, or the influence of prices on demand, or the influence of incentives, as for example in Cecere et al. (2018). In fact, understanding the opportunities and challenges that the socioeconomic reality presents to achieving the decarbonization of the transport sector is crucial if we want to achieve the goals of the 2030 Agenda for climate action, sustainable cities and communities, and affordable and clean energy for all. If the transport sector fails to decarbonize, it will be difficult to achieve these goals. For this reason, more works are needed that analyse the situation in depth and from all aspects related to supply and demand. In that sense, the effects of the demand on the policy objectives is something that has to be explored to design effective policies in order to achieve a better balance between the transport sector and the fight against climate change. As far as we know, this has been very scarcely treated in the literature, and this paper is a contribution to this debate. In other words, this work will provide a better understanding of the situation to implement energy transition policies in the transport sector that are realistic in relation to the social context in which they are applied, the time horizon they contemplate, and that, thus, can be effectively applied. Moreover, through the analysis of the case of Spain, which is interesting due to the difficulties that the penetration of clean vehicles is having in that market, this case represents an excellent case of an analysis to contribute to this knowledge.

To carry out the proposed analysis, a binomial logit model will be estimated for the period 2016 to 2019 using data of the Household Budget Expenditure (HBS) from the Spanish National Institute of Statistics (INE). The survey contains annual information on the nature and destination of household consumption expenses; more specifically, we will use data of households that spend on electricity for vehicles, as a proxy for the use of clean cars (plug-in hybrid and electric) and on fuel for vehicles, as a proxy for the use of conventional cars. The results obtained will help to characterize the consumers for electric and hybrid cars and will allow conclusions about the socioeconomic circumstances that may be advantageous or disadvantageous when we face the energy transition in the household automotive transport sector, or in other words, when clean cars have to penetrate in the market. The present study contributes to the literature on this subject by providing an empirical study of the socioeconomic and demographic characteristics of the consumers of clean vehicles. The results can be useful for designing transport policy measures that are realistic and effective, as at the moment such measures seem to be unsuccessful. One advantage that this work has, compared to most of those that have addressed this topic in the academic literature, is that it uses an official database from a large sample, representative of 11.5 households while most of the work on the subject, is based, as Oliveira and Dias (2019) point out, on their own surveys based on data from very small samples, which are therefore not very representative. Therefore, this work will provide representative results, in relation to the analysed issue, where such results are scarce.

This paper is structured as follows: in the next section the existing literature is reviewed. Section 3 presents the database used in the research, the HBS, and a descriptive analysis. Section 4 presents the estimated econometric model. Section 5 presents the results of the estimates, and the last section contains the conclusions of the study.

2. Literature review

Over the last decade, all countries have implemented policies aimed at fighting air pollution in cities and fighting climate change by promoting the use of clean vehicles. For this reason, the interest in this area of research has expanded, see, for example, Oliveira and Días (2019) and Ziegler and Abdelkafi (2022). As for the works focused on analysing issues related to the demand for clean vehicles, some are focused on analysing the determinants of demand and others on analysing the specific characteristics of the buyers. In this study we will focus on the second issue. Therefore, the literature of interest for our research evaluates the socioeconomic and demographic characteristics of consumers who buy clean vehicles. We present below a review of some of the most significant work carried out on this topic.

Liao et al. (2017) conducted a review of the literature focused on examining the factors that influence the consumption of clean vehicles. They showed that most studies worldwide show that socioeconomic, demographic, and psychological factors influence the decision to purchase a clean vehicle. The most widely applied method in this type of study is the analysis of discrete choice models in which the choice of clean vehicles is described as a choice between a group of vehicle alternatives described by their characteristics or "trade attributes".

Shabanpour et al. (2017) used a logit discrete choice model to estimate the characteristics of drivers choosing electric or gasoline vehicles in the United States using data from an own survey. They found that more educated drivers, younger drivers, and those who need to commute long-distances are more likely to choose electric vehicles.

Simsekoglu (2018), using a logistic multinomial regression, compared the characteristics of drivers of electric and conventional cars in Norway. Data were obtained from a survey of 663 drivers. The results showed that electric car owners were young, highly educated, and had a high-income level.

She et al. (2017), using a structural equation model, showed that, of the 476 respondents of their survey, the older ones had a more optimistic attitude towards electric and hybrid vehicles than the younger; in addition, the respondents with a second car in the family and those more concerned about the environment were more likely to adopt electric and hybrid vehicles.

Sovacool et al. (2018) showed, for the case of the Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), and with data from their own survey of 5,000 respondents, that 60.2 % of households that had an electric car also had a Main Breadwinner (MBW thereafter) who was single, while 85.6 % of households owning an electric car had a size of four members.

Cirillo et al. (2017), using a discrete multinomial choice model, studied the case of the State of Maryland (United States) and, based on their own survey carried out over several years with 456 respondents, showed that women with a high level of education were the most likely to buy hybrid cars.

Cecere et al. (2018), using discrete choice models applied to the cases of France, Germany, Italy, Poland, Spain and the United Kingdom, and with data from a survey carried out by the European commission Joint Research Centre in 2012 for 600 respondents in each country, obtained evidence that the intention to purchase an electric or hybrid vehicle is higher for people with higher incomes and more education.

Rodrigues et al. (2021), using a mixed logit model, showed, for the case of Portugal, and with data from their own survey of 905 drivers, that those who are most likely to choose a clean vehicle are younger people, with higher incomes, those who live in urban areas and those with higher levels of education.

Oliveira and Días (2019) made a compilation of the literature related to the characteristics of the consumers of clean vehicles, and they also estimated through a statistical analysis for the case of Portugal and based on their own survey of a sample of 105 people, that consumers with higher levels of education, women and larger families are more likely to purchase alternative fuel vehicles.

In the case of Spain, the literature that deals with this type of analysis is scarce; in fact, as far as we know, there is no study that, first, deals with the analysis of the socioeconomic characteristics of clean car buyers, understanding by clean, the electric and hybrids cars together. And second, use data from an official survey, with a very large sample, as we do in this study. However, we can highlight three works that analyse the demand for exclusively electric vehicles. Among the demand factors analysed in these works, some are socioeconomic characteristics of the buyers, and all are based on data obtained from their own surveys. Thus, Higueras-Castillo et al. (2020) analysed, through a cluster analysis, the profile of potential buyers of electric vehicles in Spain based on the data obtained in a survey of 404 respondents. They found that this profile would be defined by being a woman, being young and having a high income. Junquera et al. (2016) estimated a logit model with data from a survey of 1,245 respondents, to determine what factors influence the willingness to pay for an electric car, the only variable linked to the characteristics of consumers that was analysed is age: they found that those most likely to buy an electric car are between 24 and 45 years old. Rodríguez-Brito et al. (2018), focusing on the case of the Island of Tenerife (Spain), used data from a survey of 444 drivers and applied an analysis of principal components, clusters and a logit model to determine what factors influence the willingness to change cars for an electric one and in the willingness to pay for an electric car. Regarding socioeconomic characteristics, they found that being a man, being older, having a high income and high educational level are characteristics that determine a greater preference for electric cars than the rest of the population.

In summary, the literature seems conclusive in the positive relations between having a high level of income and other related variables, such as high educational level and household size, and buying a clean car. For other variables, such as age and gender, the literature is not conclusive. Table 1 summarizes the works analysing the characteristics of clean cars buyers, presenting the case study (country), the methodology applied, and the explanatory variables with statistical significance (for each work these explanatory variables have been marked with an X on the table).

3. Database and descriptive analysis

The database used in this research is the Households Budget Survey (HBS) designed by the Spanish National Institute of Statics (INE). The HBS contains annual information on the nature and destination of consumption expenses of households in Spain. This survey is conducted with a representative annual sample of approximately 24,000 households that represent 18.5 million households each year. The information is presented in three files that collect information on households, household members and the expenditures they make. The survey provides socioeconomic data on households and members at the national level and at the level of the Spanish Regions. Additionally, it enables the analysis of expenditure and its distribution through 4 nomenclatures, and 12 consumption groups are distinguished. It is important to note that there are several studies in the literature that, although they differ in method, use consumer spending surveys to analyse the behaviour of transport users, for example, Burguillo et al. (2017), Arranz et al. (2019; 2022).

In our study we use the information on households that spend on automotive fuel (gasoline and diesel) as a proxy for households that have a conventional car, and on those households that spend on electricity for vehicles as a proxy for ownership of electric and plug-in hybrid cars. The information covers the period from 2016 to 2019 for the 17 Spanish Regions and the two autonomous cities of Ceuta and Melilla. Each year the sample has about 13,000 households (representative of around 11.5

Table 1
Literature about the characteristics of clean car buyers.

Author	Country	Methodology	Age		Income		Labor situation	Gender		Education		Urban areas	Household size (Number of members)	Number of children
			Young	Old	lower	Higher	Employed	Woman	Man	Low	High			
Cirillo et al (2017)	United States	Multinomial Logit model	X					X			X			
Shabanpour et al. (2017)	United States	Mixed Logit Model	X			X					X			
Cecere et al. (2018)	France Germany, Spain, Italy, Poland, UK	Multinomial Logit model	X			X					X		X	
Simsekoglu (2018)	Norway	Logit model	X			X	X				X			X
Sovacool et al. (2018)	Nordic Countries	Static analysis and hypothesis proves	X				X		X		X		X	
Wolbertus et al. (2018)	Netherlands	Mixed Logit Model	X			X	X							
Junquera et al. (2016)	Spain	Logit Model	X	X										
Higueras-Castillo et al. (2020)	Spain	Conglomerate analysis	X			X		X			X			
Rodríguez-Brito (2018)	Spain	Multinomial Logit model				X			X		X			
Oliveira y Días (2019)	Portugal	Static analysis and hypothesis proves		X				X			X		X	
Rodrigues et al. (2021)	Portugal	Mixed Logit Model	X			X					X	X		
She et al. (2018)	China	Structural equations		X		X							X	

million households), and the total number of observations for the 4 years of the analysis is 53,730.

Table 2 shows descriptive information about the distribution of households that spend on automotive fuel and those that spend on electricity for vehicles. As can be seen in the entire period, 94.6 % of the households spent on automotive fuel, and 5.4 % of them spent on electricity for plug-in hybrid or electric vehicles. In other words, we observe a very low proportion of households using clean cars in the Spanish vehicle market.

Table 3 present the descriptive statistics of the variables analysed in this work, by year and for the whole period analysed respectively. The households that are most likely to spend on electricity for vehicles have a MBW male (70.7 %), older than 55 years (44.6 %), married (87.3 %), with less than one child in the household, employed (68,2%) and with higher education (34.4 %), urban areas (77.8 %), located in Andalusia (19.1 %), with an average size of 3.2 members and on average 1.3 of their members are employed. In addition, the income in quartile 1 is 16,431€ in average and 62,347€ in quartile 4. On the other hand, the profile of households that spend on fuel has a similar profile at the personal, work and family size characteristics. However, they only differ in the income profile in quartile 4 where those households in that quartile are the ones that have lower income compared to those who spend on electricity car and at a regional level this expense is more distributed: not only in Andalusia, where around 11 % of these households are located, but also higher in regions such as Catalonia, Madrid and Valencia, with around 8 %-9%.

4. Econometric model

The information in the previous section allows us to know the characteristics of the distribution of Spanish households that spend on energy to use fuel or clean vehicles according to independent characteristics, but it does not consider all the factors that influence the probability of spending on energy together, for the use of electric or plug-in hybrid vehicles, since these households can also spend on fuel. In order to isolate the effect of the different determinants on these probabilities, it is necessary to carry out the estimation of an econometric model that makes it possible to explain the probability that households spend on electric or fuel vehicles, considering both personal, work, income or household size X_{it}. With this objective, we have proceeded to estimate the unconditional probability p_{it} that a Spanish household spends on electricity for a vehicle, subject to a set of characteristics X_{it} in

Table 2
Households spending on fuel or electricity for vehicles by years and period 2016–2019.

YEARS	2016		2017		2018		2019		2016–2019	
	No.	%	No.	%	No.	%	No.	%	No.	%
Households spending on fuel for vehicles	13,209	95.5 %	12,752	92.3 %	12,802	96.1 %	12,088	94.8 %	50,851	94.6 %
Households spending on electricity for vehicles	617	4.5 %	1,070	7.7 %	523	3.9 %	669	5.2 %	2,879	5.4 %
Total households using cars	**13,826**	**100 %**	**13,822**	**100 %**	**13,325**	**100 %**	**12,757**	**100 %**	**53,730**	**100 %**

Table 3
Descriptive statistics of households that spend on fuel and/or electricity for vehicles by years and for the whole period analysed respectively.

Variables	Households that spend on fuel (Mean)					Households that spend on electricity (Mean)				
	2016	2017	2018	2019	2016–2019	2016	2017	2018	2019	2016–2019
Gender MBW (Male = 1)	0.734	0.738	0.739	0.731	0.736	0.747	0.693	0.719	0.683	0.707
MBW age (in years)										
18 to 30	0.023	0.024	0.022	0.020	0.022	0.028	0.021	0.013	0.019	0.021
>30 to 45	0.278	0.262	0.257	0.252	0.262	0.191	0.228	0.229	0.259	0.228
>45 to 54	0.244	0.244	0.244	0.247	0.244	0.274	0.283	0.283	0.226	0.268
55 or more	0.425	0.443	0.447	0.452	0.442	0.460	0.428	0.449	0.459	0.446
Income home (proxy spending)										
Income Quartile 1	16,678	16,783	16,793	16,759	16,750	17,022	16,223	16,099	16,487	16,431
Income Quartile 2	26,290	26,273	26,209	26,394	26,289	26,160	26,498	26,657	26,658	26,470
Income Quartile 3	36,313	36,392	36,421	36,475	36,398	36,014	36,698	36,426	36,546	36,461
Income Quartile 4	58,935	59,855	59,608	59,824	59,562	62,728	62,194	61,821	62,754	62,347
Household residence area (Rural = 1)	0.255	0.250	0.248	0.244	0.249	0.227	0.230	0.235	0.193	0.222
Number of employed members in the household	1.215	1.236	1.258	1.277	1.246	1.335	1.374	1.258	1.290	1.325
Number of children in the household	0.761	0.729	0.723	0.727	0.735	0.906	0.956	0.790	0.788	0.876
Number of household members	2.973	2.916	2.918	2.914	2.931	3.357	3.380	3.092	3.036	3.243
Level of studies completed MBW										
Primary	0.150	0.148	0.138	0.136	0.143	0.194	0.174	0.128	0.138	0.162
Secondary I stage	0.307	0.300	0.298	0.280	0.297	0.300	0.326	0.285	0.286	0.304
Secondary stage II	0.193	0.193	0.194	0.192	0.193	0.190	0.192	0.172	0.205	0.191
Higher Education (University)	0.350	0.359	0.369	0.392	0.367	0.316	0.308	0.415	0.372	0.344
Situation labor MBW (Occupied = 1)	0.669	0.675	0.673	0.686	0.675	0.637	0.712	0.669	0.685	0.682
Marital status MBW (Single = 1)	0.163	0.170	0.167	0.170	0.167	0.100	0.121	0.143	0.148	0.127

	Households that spend on fuel (Mean)					**Households that spend on electricity (Mean)**				
	2016	**2017**	**2018**	**2019**	**2016–2019**	**2016**	**2017**	**2018**	**2019**	**2016–2019**
Region of residence										
Andalusia	0.117	0.112	0.112	0.118	0.115	0.147	0.192	0.224	0.203	0.191
Aragon	0.040	0.042	0.046	0.049	0.044	0.000	0.019	0.002	0.010	0.010
Asturias	0.036	0.034	0.035	0.037	0.036	0.010	0.019	0.027	0.006	0.015
Balearic Islands	0.039	0.038	0.037	0.030	0.036	0.034	0.059	0.027	0.069	0.050
Canary Islands	0.049	0.049	0.049	0.047	0.049	0.079	0.079	0.036	0.085	0.073
Cantabria	0.033	0.036	0.034	0.032	0.034	0.013	0.024	0.076	0.063	0.040
Castile and Leon	0.060	0.062	0.060	0.058	0.060	0.042	0.036	0.034	0.025	0.035
Castile-La Mancha	0.058	0.060	0.059	0.055	0.058	0.050	0.047	0.038	0.022	0.040
Catalonia	0.089	0.090	0.083	0.082	0.086	0.079	0.091	0.042	0.033	0.066
Valencian region	0.079	0.083	0.081	0.081	0.081	0.024	0.012	0.008	0.027	0.017
Extremadura	0.049	0.043	0.043	0.042	0.044	0.057	0.056	0.092	0.100	0.073
Galicia	0.061	0.062	0.062	0.059	0.061	0.058	0.054	0.088	0.075	0.066
Madrid region	0.078	0.089	0.087	0.092	0.086	0.159	0.036	0.042	0.036	0.064
Murcia	0.046	0.046	0.048	0.049	0.047	0.049	0.093	0.065	0.102	0.081
Navarre	0.031	0.032	0.033	0.032	0.032	0.057	0.017	0.057	0.033	0.036
Basque Country	0.092	0.083	0.091	0.095	0.090	0.097	0.103	0.099	0.069	0.093
La Rioja	0.033	0.030	0.029	0.028	0.030	0.023	0.045	0.031	0.028	0.034
Ceuta	0.005	0.004	0.004	0.005	0.005	0.011	0.009	0.011	0.007	0.010
Melilla	0.006	0.005	0.007	0.005	0.006	0.010	0.008	0.000	0.006	0.007
Sample (Households)	13,209	12,752	12,802	12,088	50,851	617	1,070	523	669	2,879

Source: HBS and own elaboration.

period t:

$$p_{it} = f(\beta_1 + \beta_2 + X_{it}) \tag{1}$$

The calculation of this probability is carried out by estimating a binomial logit model, in which the endogenous variable (Y) takes two values: 0 and 1. In our analysis, 1 is assigned to the people who spend on electricity for a vehicle and 0 to those who spend on automotive fuel. Formally, the logit model is

$$Y = F(\beta_1 + \beta_2 X_{it}) + \varepsilon = \frac{1}{1 + e^{-(\beta_1 + \beta_2 X_{it})}} + \varepsilon \tag{2}$$

where the probability that a household spends on electricity for a vehicle in period t is

$$p_{it} = E(Y = 1|X_{it}) = \frac{1}{1 + e^{-(\beta_1 + \beta_2 X_{it})}} \tag{3}$$

The estimates have been made for all the years from 2016 to 2019 using the maximum likelihood method. The estimated models include a set of explanatory variables such as age, gender, marital status, level of studies completed and employment status of the MBW, residential area of the household, number of employed members of the household, number of children in the household, income per household and Region of residence.

5. Empirical results

Table 4 provides the results of the estimates of the probability that a household spends on electricity for its vehicle versus on fuel, for the entire sample of households. In the table, the odds ratios and the coefficients of each category are shown. If the odds ratio has a value lower (higher) than 1, this indicates that the household is less (more) likely to spend on electricity for its vehicle, compared to the reference category (spending on fuel for your vehicle).

The results of Table 4 show that the households with a higher probability of spending on clean vehicles compared to conventional vehicles are the following:

Regarding gender, the probability that a household whose MBW is a man uses a clean vehicle increases by 3.5 % compared to the probability that a household whose MBW is a woman. This result coincides with the analysis of Rodríguez-Brito et al. (2018) of the case of Tenerife (Spain).

Table 4
Estimation of the probability (logit model) that a household spends on electricity for vehicles versus spending on automotive fuel.

Variables	*Coefficients*	*Odss Ratio*
MBW gender		
Men	0.035***	1.035***
	(0.008)	(0.008)
MBW age groups (in years)		
18—30	0.216	1.241
	(0.143)	(0.177)
>30—45	–	–
>45—54	0.140**	1.150**
	(0.054)	(0.061)
55 or more	0.255***	1.291***
	(0.057)	(0.074)
MBW Marital Status		
single	−0.201***	0.818***
	(0.064)	(0.052)
Number of employed members	0.080***	1.083***
	(0.025)	(0.026)
Number of children	0.131***	1.140***
	(0.023)	(0.026)
Income		
Quartile 1	−0.233***	0.791***
	(0.059)	(0.046)
Quartile 2	−0.346***	0.707***
	(0.057)	(0.040)
Quartile 3	−0.236***	0.790***
	(0.053)	(0.042)
Quartile 4	–	–
Zone		
Rural zone	−0.108**	0.897***
	(0.049)	(0.044)
Variables	*Coefficients*	*Odss Ratio*
Region		
Andalusia	–	–
Aragon	−2.023***	0.132***
	(0.196)	(0.025)
Asturias	−1,330***	0.264***
	(0.159)	(0.042)
Balearic Islands, Illes	−0.197**	0.821**
	(0.098)	(0.080)
Canary Islands	−0.087	0.917
	(0.085)	(0.078)
Cantabria	−0.325***	0.722***
	(0.107)	0.077
Castile and Leon	−1.041***	0.353***
	(0.112)	(0.039)
Castilla la Mancha	−0.849***	0.427***
	(0.105)	(0.045)
Catalonia	−0.814***	0.443***
	(0.087)	(0.038)
Community Valencian	−2.057***	0.127***
	(0.149)	(0.019)
Estremadura	0.053	1,054
	(0.087)	(0.091)
Galicia	−0.419	0.657***
	(0.088)	(0.057)
Madrid region	−0.879***	0.415***
	(0.089)	(0.036)
Murcia	−0.004	0.990
	(0.083)	(0.082)
Navarre	−0.401***	0.669***
	(0.112)	(0.074)
Basque Country	−0.528***	0.589***
	(0.078)	(0.046)
The Rioja	−0.369***	0.691***
	(0.115)	(0.079)
Ceuta	0.137	1.146
	(0.206)	(0.236)
Melilla	−0.473**	0.623***
	(0.242)	(0.150)
Constant	−2.551	0.077
	(0.092)	(0.007)
Sample	53,730	
Log-likelihood	−10783.004	

i) Standard errors are presented in parentheses.
ii) Significance level: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

In any case, the literature is not conclusive regarding the gender, as was seen in Section 2.

The age of the MBW of the household has effects on the probability of using a clean car. In fact, the effect shows a U-shaped relation, that is, households with the youngest and oldest MBWs have a greater probability of acquiring a clean vehicle than the rest of the households. Thus, the probability that a household uses a clean vehicle is greater when the MBW is older than 55, or younger than 30. This probability compared to the probability that a household whose MBW is between 30 and 44 years old increases by 29.1 % in the first case and 24.1 % in the second case. In addition, that probability is 15 % if the MBW is between 30 and 44 years old. This result agrees with other works in the literature such as that of Sovacool et al. (2018) which shows that in the Nordic countries older people and recently retired people drive short distances, have high car budgets and are less interested in design, and Simsekoglu (2018), finding, for Norway, that the youngest are those with the highest probability of buying a clean car.

Regarding marital status, the probability that a household whose MBW is single uses a clean vehicle decreases by 18.9 % compared to the probability that a household whose MBW is married uses it. This result agrees with others in the literature, which explain that, among single people, who generally do not have children, there may be less concern for the environment and for the future (Büchs and Schnepf, 2013).

Table 4 also shows that income level is a socioeconomic factor that positively influences the acquisition of clean vehicles. Thus, the probability that low-income households (quartile 1) and medium income (quartile 3) use a clean vehicle decreases by 21.0 % compared to high-income households (quartile 4), and the probability of low-middle income households (quartile 2) decreases by 29.3 %. The existing literature shows that income tends to have a positive influence on the adoption of clean vehicles, and it is also in relation to this factor that the literature, as pointed out in Section 2, seems to be more conclusive. For works focused on Spain, Rodríguez Brito et al. (2016) and Higueras-Castillo et al. (2020) obtained similar results: they explain that the reason why higher incomes and the purchase of clean cars are positively related is that consumers with higher incomes can more easily bear the higher costs derived from the adoption of ecological products and produced with more advanced technology, see for example, Straughan and Roberts (1999), Tellis and Yin (2009), and Lennon et al. (2007). Also, there are works that emphasizes that high-income consumers are more likely to be aware of environmental issues, as for example, Straughan and Roberts (1999). Regarding the results by quartiles, these data would agree with those obtained by Burguillo et al. (2017) that show that Spanish households from the second quartile are more dependent on the use of fuel vehicles. This would explain why their probability of using a clean vehicle decreases more with respect to households in the richest quartile, as does also the probabilities of the 1st and 3rd quartile households.

The probability that a household with a greater number of its members employed uses a clean vehicle increases by 8.3 % with respect to households that have fewer employed members. This result is common in the literature. For example, Morton et al. (2017) find that the people that are most likely to be early adopters of electric vehicles are employed full-time workers, and Gough and Meadowcroft (2011) find that unemployment is negatively associated with carbon emissions.

The probability that a household with a greater number of children uses a clean vehicle increases by 14.0 % compared to the probability of households with fewer children. The explanation is that, first it seems that families with children are more willing to pay more for environmental products due to their concerns about the negative impact of a destroyed environment on their children's future (Laroche et al., 2001). And second, it seems that for the safety of household members, larger households appear to have more cars and are willing to pay more for them (Sovacool et al. 2018). On the other hand, the probability that a household located in a rural area uses a clean vehicle decreases by 10.3 % compared to the probability that a household located in an urban area uses it. This result also agrees with other results in the literature, for example, Rodrigues et al. (2021) for the case of Portugal. This is logical result because in rural areas it is usually necessary to make longer and more frequent trips in private vehicles, and the problem of the autonomy of electric vehicles and the absence of the advantages that hybrids can have in urban areas (due to lower consumption of fuel) are lost in the rural context.

Finally, in relation to the results by region, we have taken Andalusia as the reference region. Thus, as can be seen in Table 4, households living in all the other regions have a lower probability of using a clean vehicle than a household in Andalusia. The regions in which the probability of using a clean vehicle decreases more compared to the probability of using it in Andalusia, are the Valencian Community and Aragón, whose probabilities decrease by 87.3 % and 86.8 % respectively. As for Madrid and Catalonia, the probability that clean vehicles are used there compared to Andalusia decreases by 58.5 % and 55.7 %, respectively.

6. Conclusions

Given the importance that the transport sector has in the economy as a whole, and in energy consumption in particular, achieving the decarbonization of transport is crucial if the objectives climate action, sustainable cities and communities, and affordable and clean energy for all are to be achieved by 2030. Going deeper into the knowledge of the factors that, beyond those linked to public policies, or to relative prices, explain the purchase of clean vehicles, is necessary in order to have a better understanding of the challenges and opportunities that today's society presents to adapting to the changes that the achievement of the objectives of the 2030 Agenda requires. With this purpose in mind, this paper has presented an analysis of the socioeconomic and demographic characteristics of those households that are more likely to purchase a clean vehicle in Spain. To carry out this analysis, a binomial logit model has been estimated with data from the Households Budget Survey of the Spanish National Institute of Statistics for the years 2016 to 2019, which contains annual information on the nature and destination of household consumption expenditures.

To sum up, we can estate that the results of this study show that the households that are most likely to spend on automotive electricity, that is, to use a clean car, are those whose socioeconomic characteristics are the following: households with a main breadwinner (MBW) over 55 years of age or under 30, who is male, and who is married; households with a high level of income, living in urban areas, with a greater number of members employed (the average is 1.3 employed members), with a greater number of children, and who live in Andalusia. On the contrary, households whose MBW is between 31 and 44 years old, is female, is single, is a medium–low-income household (second quartile), located in a rural area, with a lower number of employed members, with a lower number of children and who live in Aragon or Valencia are less likely to have an electric or hybrid car. These results are consistent with others found in the literature analysed for various countries. These results are conclusive in the variables linked to income level, while for others, such as age or gender, there is controversy. One advantage of this study, compared to most studies in the literature, is that it uses data from an official survey for a very large sample of households, while most of the studies are based on data from surveys with relatively small samples.

From these results, conclusions can be drawn about the opportunities and challenges that some of them present to achieving the decarbonization of the sector by 2030 in Spain. For example, the fact that older age is a positive socioeconomic characteristic for buying a clean car can be a help for the decarbonization of the transport sector since the number of older people in Western societies is on the rise, and so there will be a greater proportion of the population favourably disposed to buying clean vehicles. In addition, it is also favourable that the youngest, whose behaviour defines the trend of global behaviour in the future, are also likely to purchase this type of vehicle. Another positive factor could be linked to the fact that men seem more likely to use clean cars, for households with male MBW are also those with more combustion vehicles, specifically in 73.6 % of households using combustion vehicles the MBW is a man (see Table 3). It is important that the largest car buyers, who according to these data are men, are also the ones who are buying to a greater extent clean cars. This fact marks a positive opportunity for the development of the clean vehicle market, since it indicates that men, who seem to have a greater preference for cars than women, also have a preference for clean vehicles. In any case, the greatest challenge outlined by these results comes from the positive relation found between the level of income and other correlated variables, and the use of clean vehicles. Indeed, from the results of this work it can be deduced that no matter how many economic incentives are given to acquire clean vehicles, in the end, as is the case in Spain, having a high level of income is key to acquiring them.

7. Policy implications

From the results of this work can be extracted some public policy implications that can be useful for implementing a more realistic design of the policy measures aiming to an energy transition of the transport sector.

As it is well known, achieving the gradual replacement of the automobile fleet based on the combustion of petroleum derivatives for a cleaner one is very important in order to achieve three of the objectives of the 2030 Agenda: climate action, sustainable cities and communities, and affordable and clean energy for all. The three objectives may be interrelated, since households with low levels of income would have difficulties to buy cleaner electric cars as they are also more expensive. These trade-offs are a well-known issue in achieving the goals of the so-called energy trillema (access to energy, clean energy and affordable energy). In that sense, the social pillar of energy transitions policies, or in other words reaching a just energy transition, is a key factor for the effectiveness of such objective.

In fact, in many countries the market for clean vehicles is not increasing as expected despite public subsidies and incentives, and awareness policies such as advertising campaigns, among others, that encourage their purchase. This is the case of Spain, where this work is focused, clean vehicles represented just 2.7 % of the total number of vehicles in the country in 2020, and between 2016 and 2019 only 5.4 % of households using cars used a clean one. The situation at that time suggests that it will be very difficult to reach the objective set for 2030, which is to achieve a percentage of 16 % of clean vehicles. The results of this work suggest that beyond thecnological issues, the low uptake of electric vehicles has to do with the difficulties that low and medium-income households face to acquire an electric car.

In that sense the 2030 Agenda objective of climate action, in whose achievement the transport sector plays a fundamental role due to its dynamics of GHG emissions, can be opposed, as this work shows, to the objective of achieving affordable and clean energy for all in 2030. Therefore, policy makers must have a better understanding of the socioeconomic reality in which they want to implement certain measures, and propose measures adapted to such reality. These measures should be coherent with each other and feasible in the time frame in which they are proposed. Thus, while the automobile industry is improving technology, allowing greater autonomy of vehicles and a lower price in relation to traditional combustion vehicles, policy makers in the different countries, even continuing to implement policies both for the supply (installation of charging points) and demand (economic incentives for acquisition, awareness campaings etc) sides that prompt the acquisition of electrid cars, should, maybe, enlarge the time horizon to reach a certain level of electric cars market penetration. In that sense, on the grounds of just and sociably acceptable measures the date of 2030 should be reconsidered for reaching in Spain a 16 % clean vehicles.

Moreover, subsidies should particularly target lower-income households (in Spain the current subsidies scheme do not considerer income level), the ones which are most at risk of being locked into reliance on fossil fuels.

To sum up, this research provides useful information to policy makers so that they consider results such as these for designing realistic policies adapted to the social environment that allow a harmonious and socially acceptable balance between the transport sector and the fight against climate change.

CRediT authorship contribution statement

José M. Arranz: Supervision, Methodology, Software, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization. **Mercedes Burguillo:** Conceptualization, Methodology, Supervision, Investigation, Project administration, Writing – original draft, Writing – review & editing, Visualization. **Jeniffer Rubio:** Software, Formal analysis, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

ACEA, 2020. European Automobile Manufacturers' Association . New passenger car registrations by fuel type in the European Union. Available at https://www.acea.be.

Adepetu, A., Keshav, S., 2017. The relative importance of price and driving range on electric vehicle adoption: Los Angeles case study. Transportation 44 (2), 353–373.

ANFAC, 2021. Spanish Association of Automobile and Truck Manufacturers. ANFAC Barometer of Electo-Movilidad second semester 2021. Available at: https://anfac.com/wp-content/uploads/2021/09/Barometro-Electromovilidad-2T-2021.pdf.

Arranz, J.M., Burguillo, M., Rubio, J., 2019. Subsidization of public transport fares for the young: An impact evaluation analysis for the Madrid Metropolitan Area. Transportation Policy 74, 84–92.

Arranz, J.M., Burguillo, M., Rubio, J., 2022. Are public transport policies influencing the transport behavior of older people and economic equity) A case study of the Madrid Region?, Research in Transportation Economics, 95, November, 201218.

Bienias, K., Kowalska-Pyzalska, A., Ramsey, D., 2020. What do people think about electric vehicles? An initial study of the opinions of car purchasers in Poland. Energy Rep. 6, 267–273.

Bjerkan, K.Y., Norbech, T.E., Nordtomme, M.E., 2016. Incentives for promoting battery electric vehicle (BEV) adoption in Norway. Transp. Res. Part D: Transp. Environ. 43, 169–180.

Büchs, M., Schnepf, S.V., 2013. Büchs, M., Schnepf, S.V., 2013. Who emits most? Associations between socio-economic factors and UK households' home energy, transport, indirect and total CO2 emissions. Ecol. Econ. 90, 114–123.

Burguillo, M., del Río, P., Romero-Jordán, D., 2017. Car use behavior of Spanish households: Differences for quartile income groups and transport policy implications. Case Studies on Transport Policy 5 (1), 150–158.

Cecere, G., Corrocher, N., Guerzoni, M., 2018. Price or performance? A probabilistic choice Analysis of the intention to buy electric vehicles in European countries. Energy Policy 118, 19–32.

Cirillo, C., Liu, Y., Maness, M., 2017. A time-dependent stated preference approach to measuring vehicle type preferences and market elasticity of conventional and green vehicles. Transp. Res. A Policy Pract. 100, 294–310.

European Comission. Transport emissions, 2021. Available online: https://ec.europa.eu/commission/presscorner/api/files/attachment/869813/EGD_brochure_ES.pdf.pdf.

Cox, B., Mutel, C.L., Bauer, C., Mendoza Beltran, A., van Vuuren, D,P., 2018. Uncertain environmental footprint of current and future battery electric vehicles. Environmental Science & Technology, 52(8), 4989-4995.

Egbue, O., Long, S., 2012. Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. Energy Policy 48, 717–729.

Fang, Y., Wei, W., Mei, S., Chen, L., Zhang, X., Huang, S., 2020. Promoting electric vehicle charging infrastructure considering policy incentives and user preferences: An evolutionary game model in a small-world network. J. Clean. Prod. 258, 120753.

Franke, T., Krems, J.F., 2013. Interacting with limited mobility resources: Psychological range levels in electric vehicle use. Transp. Res. A Policy Pract. 48, 109–122.

Gough, I., Meadowcroft, J., 2011. Decarbonizing the welfare state. Oxford University Press. 490–503.

Hackbarth, A., Madlener, R., 2013. Consumer preferences for alternative fuel vehicles: A discrete choice analysis. Transp. Res. Part D: Transp. Environ. 25, 5–17.

Higueras -Castillo, E., Molinillo, S., Coca - Stefaniak , J.A., Liebana-Cabanillas , F., 2020. Potential Early Adopters of Hybrid and Electric Vehicles in Spain—Towards a Customer Profile. Sustainability, 12(11), 4345.

Junquera, B., Moreno, B., Álvarez, R., 2016. Analyzing consumer attitudes towards electric vehicle purchasing intentions in Spain: Technological limitations and vehicle confidence. Technol. Forecast. Soc. Chang. 109, 6–14.

Knobloch, F., Hanssen, S.V., Lam, A., Pollitt, H., Salas, P., Chewpreecha, U., Mercure, J. F., 2020. Net emission reductions from electric cars and heat pumps in 59 world regions over time. Nat. Sustainability 3 (6), 437–447.

Laroche, M., Bergeron, J., Barbaro-Forleo, G., 2001. Targeting consumers who are willing to pay more for environmentally friendly products. J. Consum. Mark. 18 (6), 503–520.

Lennon, S.J., Kim, M., Johnson, K.K., Jolly, L.D., Damhorst, M.L., Jasper, C.R., 2007. A longitudinal look at rural consumer adoption of online shopping. Psychol. Mark. 24 (4), 375–401.

Levay, P.Z., Drossinos, Y., Thiel, C., 2017. The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership. Energy Policy 105, 524–533.

Li, J., Zhao, X., Cho, M.J., Ju, W., Malle, B.F., 2016. From trolley to autonomous vehicle: Perceptions of responsibility and moral norms in traffic accidents with self-driving cars. SAE Technical Paper 10, 2016–12001.

Liao, F., Molin, E., van Wee, B., 2017. Consumer preferences for electric vehicles: A literature review. Transp. Rev. 37 (3), 252–275.

Ministry for the Ecological Transition and the Demographic Challenge, 2020) National Integrated Energy and Climate Plan, 2021-2030. Madrid.

Morton, C., Anable, J., Nelson, J.D., 2017. Consumer structure in the emerging market for electric vehicles: Identifying market segments using cluster analysis. Int. J. Sustain. Transp. 11 (6), 443–459.

Münzel, C., Plötz, P., Sprei, F., Gnann, T., 2019. How large is the effect of financial incentives on electric vehicle sales?– A global review and European analysis. Energy Econ. 84, 104493.

Oliveira, G.D., Dias, L.C., 2019. Influence of demographics on consumer preferences for alternative fuel vehicles: a review of choice modeling studies and a study in Portugal. Energies 12 (2), 318.

Potoglou, D., Kanaroglou, P.S., 2007. Household demand and willingness to pay for clean vehicles. Transp. Res. Part D: Transp. Environ. 12 (4), 264–274.

Rodrigues, R., Moura, F., Silva, A.B., Seco, Á., 2021. The determinants of Portuguese preference for vehicle automation: A descriptive and explanatory study. Transport. Res. F: Traffic Psychol. Behav. 76, 121–138.

Schneidereit, T., Franke, T., Günther, M., Krems, J.F., 2015. Does range matter? Exploring perceptions of electric vehicles with and without a range extender among potential early adopters in Germany. Energy Res. Soc. Sci. 8, 198–206.

Shabanpour , R., Mousavi, S.N.D., Golshani, N., Auld, J., Mohammadian , A., 2017. Consumer preferences of electric and automated vehicles. In 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS). IEEE, pp. 716-720.

She, Z.Y., Sun, Q., Ma, J.J., Xie, B.C., 2017. What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China. Transp. Policy 56, 29–40.

Simsekoglu, Ö., 2018. Socio-demographic characteristics, psychological factors and knowledge related to electric car use: A comparison between electric and conventional car drivers. Transp. Policy 72, 180–186.

Sovacool, B.K., Kester, J., Noel, L., de Rubens, G.Z., 2018. The demographics of decarbonizing transport: The influence of gender, education, occupation, age, and household size on electric mobility preferences in the Nordic region. Glob. Environ. Chang. 52, 86–100.

Straughan, R.D., Roberts, J.A., 1999. Environmental segmentation alternatives: a look at green consumer behavior in the new millennium. J. Consum. Mark. 16 (6), 558–575.

Tellis, G.J., Yin, E., Bell, S., 2009. Global consumer innovativeness: Cross-country differences and demographic commonalities. J. Int. Mark. 17 (2), 1–22.

UNESPA, 2022. En España circulaban 674.000 coches híbridos y eléctricos en 2020. https://www.unespa.es/notasdeprensa/automovil-tipos-motor-2020/ (accessed 13 September 2022).

Vassileva, I., Campillo, J., 2017. Adoption barriers for electric vehicles: Experiences from early adopters in Sweden. Energy 120, 632–641.

Wang, N., Tang, L., Pan, H., 2019. A global comparison and assessment of incentive policy on electric vehicle promotion. Sustain. Cities Soc. 44, 597–603.

White, L.V., Sintov, N.D., 2017. You are what you drive: Environmentalist and social innovator symbolism drives electric vehicle adoption intentions. Transp. Res. A Policy Pract. 99, 94–113.

Wolbertus, R., Kroesen, M., Van Den Hoed, R., Chorus, C., 2018. Fully charged: An empirical study into the factors that influence connection times at EV-charging stations. Energy Policy 123, 1–7.

Ziegler, D., Abdelkafi, N., 2022. Business models for electric vehicles: Literature review and key insights. J. Clean. Prod. 330, 129803.