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Influence of Demographics on Consumer Preferences for Alternative Fuel Vehicles: A Review of Choice Modelling Studies and a Study in Portugal

Gabriela D. Oliveira [1,2,3,*] and Luis C. Dias [2,3]

1 DEM—Mechanical Engineering Department, University of Coimbra, Coimbra 3030-788, Portugal
2 CeBER and Faculty of Economics, University of Coimbra, Coimbra 3004-512, Portugal; lmcdias@fe.uc.pt
3 INESCC—Institute for Systems Engineering and Computers at Coimbra, Coimbra 3030-290, Portugal
* Correspondence: gdoliv@fe.uc.pt

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Abstract: The significant energy consumed by road transportation and the difficult market penetration of Alternative Fuel Vehicles (AFVs) has led to a substantial body of research aiming to understand consumer preferences and future demand for AFVs. The individual characteristics of consumers are one of the explanatory factors of these preferences. In this context, the main purpose of this work is to present a comprehensive state-of-the-art review of how consumer demographics influence their preferences concerning AFVs. This review focuses on papers that applied Choice Modelling techniques to elicit individual consumer preferences for AFVs through stated preference surveys. Age, gender, income, level of education, family size, driving habits and number of vehicles per household were selected for analysis. This study also adds to the literature by analyzing the influence of demographic characteristics on preferences of Portuguese consumers. Very few studies addressed the influence of demographics on preferences for vehicle attributes. Considering the influence of consumers' income and age, no consistent results were found. However, when age and consumers' nationality were crossed, a potential trend of consumers' age influence was unveiled. Regarding gender, level of education and family size, it was observed that consumers with higher education levels, women and consumers with larger families have higher preferences for AFVs.

Keywords: consumer preferences; alternative fuel vehicles; electric vehicles; choice modelling; demographic influence; literature review

1. Introduction

Road transportation is the largest energy consumer in the transport sector, e.g., representing 82% of energy consumed in Europe [1]. Since most vehicles on the road use fossil fuels, this entails environmentally harmful emissions contributing to climate change and other undesirable externalities. As the impact of the transport sector on global climate change is expected to significantly worsen in the short-medium term, a rapid energy use transition is demanded in this sector [2]. The aim of mitigating the environmental burden from transportation led to the development of several plans. For instance, the EU defined the Climate and Energy Package 2020 where specific targets for the transports sector mandated that, in 2020, 10% of the energy used in this sector would be from renewable sources. Alternative Fuel Vehicles (AFVs) can contribute to overcoming the environmental problem through the gradual substitution of fossil fuels by potentially more environmentally sustainable energy carriers, such as electricity, hydrogen or ethanol [3,4]. However, the adoption of new technologies in the transports field worldwide has been hindered by technical and investment related concerns [5–7], despite large investments made by governments to increase the diffusion of AFVs, such as building

refuelling infrastructures, giving incentives for vehicles production and for consumers' purchases (e.g., subsidies, exemption of taxes). In the European Union a low adoption of AFVs has been observed, with AFVs representing only 4.1% of Light Duty Vehicles (LDVs) total sales in 2016 [8]. Even in the US, where the first programs to encourage the purchase of environmentally friendly vehicles started with the Zero Emission Vehicle mandate in 1990s, AFVs sales are still far from what was expected [9]. This calls into question the ability of governments to achieve environmental targets they committed to in order to significantly reduce the CO_2 emissions released from road transportation.

Sales figures show that although AFVs are seen as promising technologies, they have had difficulty in penetrating the markets. These difficulties come from both supply and demand sides of the market. On the supply side, consumers are mainly concerned with the availability of AFV models that may satisfy their requirements, despite the number of AFVs models had been increasing in the market the AFVs diversity at consumers' disposal is still far behind the Internal Combustion Engine Vehicles (ICEVs) availability, and with the existence of the appropriate infrastructure to charge/refuel AFVs [10,11].

On the demand side, consumer preferences have been considered as the most relevant factor that could be used to predict changes in the vehicles market [3]. Moreover, the unfamiliarity of consumers with AFVs is another barrier that influences consumers demand, by leading to scepticism beforehand [12–14]. In this context, it is crucial to understand how effective market policies can be designed in order to overcome these barriers and promote AFV sales. This highlights the importance of understanding consumer preferences as a path to achieve a CO_2 emissions reduction from road transports [15], by identifying which consumers have higher propensity to choose these vehicles [5].

Ewing and Sarigöllü [16] pointed out that preferences for different vehicles vary between market segments, so it is expected that different types of consumers respond differently to AFVs. The individual characteristics of consumers are one of the dimensions responsible for this diversity [17], and understanding in which way individual characteristics influence consumer preferences allows to uncover the existent market segments [18]. Findings from such studies provide detailed information that can be used to design incentive policies and to develop marketing strategies to influence preferences among the consumers willing to buy AFVs [19].

In this context, the main objective of this paper is to present a comprehensive state-of-the-art review of how consumer demographics influence their preferences concerning AFVs and their attributes. Recently, there has been an increasing number of studies that aimed at uncovering consumer preferences for greener vehicles (e.g., [17,19–26]) highlighting how important it is to understand consumers' willingness to adopt AFVs. Among the most commonly used techniques to elicit consumer preferences is Choice Modelling (CM), also known as Conjoint Analysis, that use Stated Preference (SP) data as inputs, i.e., designed experiments that measure preferences of hypothetical products that are not yet in the market [27]. CM uses experiments where consumers screen a range of products to choose, rank or rate according to their preferences [28]. Given the growing literature on CM studies for AFVs, the second objective for this review is to identify trends in the consumer preferences studies selected for analysis. Among all the reviewed studies, a lack of studies focused on Portuguese market was identified, where only one study addressed consumer preferences for AFVs in Portugal, namely Braz da Silva and Moura [29]. However, as this study did not analyze the influence of demographic characteristics on Portuguese preferences for AFVs, and results from other studies cannot be extrapolated because the influence of demographics on consumer preferences differs among countries, and given the Portuguese context of hard penetration of AFVs further detailed in Section 6, the third and final objective of this paper is to provide such analysis.

This paper is organized as follows. Section 2 briefly presents previous studies that reviewed several aspects of consumer preferences for AFVs. The research strategy for the present study is described in Section 3. Section 4 presents consumer preference studies as well as trends in this area of study. The influence of individual characteristics on preferences for AFVs is presented in Section 5.

Section 6 presents the new study for Portugal. Conclusions are presented in Section 7 and the main research gaps follow in Section 8.

2. Previous Review Studies

During the last three decades, an extensive body of research has aimed at understanding consumer preferences and future demand for AFVs. Potoglou and Kanaroglou [30] did an overview of the methodological aspects of choice-based models for vehicle demand. They reviewed data collection methods (stated and revealed preferences), modelling approaches (vehicle-type choice models, vehicle-holding models and vehicle-transaction models) and also some explanatory factors of vehicle demand, such as place of residence. Al-alawi and Bradley [31] focused their study on Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) market penetration literature by reviewing the most commonly used modelling techniques for market forecasting, namely agent-based models, consumer choice models, diffusion rate and time series models. A thorough review of attitudinal, experimental and preference studies is given by Turcksin et al. [27] in order to understand what the consumer attitudes and preferences for AFVs are. These authors presented the attributes, scope (type of focused vehicles), methodology applied, main findings and study location of consumer preference studies. Despite not being a review article, Hoen and Koetse [18] provide a relevant review of the main aspects of survey designs of conjoint preference studies about AFVs (type of questions, vehicles compared and selected attributes) that is useful to identify trends in these types of studies. A comprehensive overview of supportive factors and barriers to consumer adoption of AFVs was presented by Rezvani et al. [32], who reviewed the factors (attitudinal, innovative, symbolic, emotional and pro-environmental factors) that influence consumer behavior towards or against the adoption of Electric Vehicles (EVs) (in this article we use EVs as a generic class encompassing BEVs, HEVs and PHEVs). More recently, Liao et al. [33] reviewed consumer preference studies for EVs in order to suggest stronger policies to promote EVs. This review covered several topics such as the techniques used to model preferences for EVs, the preferences for attributes of EVs and the factors that account for heterogeneous preferences, namely socio-economic and demographic characteristics, psychological factors, EVs experience and social influence.

In summary, previous reviews have focused on consumer adoption and preferences for AFVs, from methodological trends in modelling preferences to explanatory factors of those preferences. However, to the authors' best knowledge, a review of the influence of individual characteristics of consumers on their preferences for AFVs has not been addressed in depth, while a review of the influence of these characteristics on preferences for vehicle attributes was never performed. Therefore, the review presented in this paper aims at filling these gaps.

3. Data Collection Strategy

As stated in the introduction, the main objective of this paper is to present a comprehensive state-of-the-art review of how consumer demographics influence their preferences concerning AFVs and their attributes. As the literature on consumer preferences for alternative vehicle technologies is very extensive, the review focuses on choice modelling methodologies, which are the most used group of methods to elicit preferences in the field. The reviewed studies consider mainly stated preference data, which is usual when inquiring about innovative products with scarce sales data.

Only studies published in peer-reviewed journals were considered. The study selection was done in two phases (Figure 1). The first phase comprised a Scopus®database search in the studies' title, abstract and keywords (last access in October 2018). The following keywords combination was used: "vehicle" with "preference" or "demand" and either "choice" or "conjoint." The search was limited to studies published in journals and in English. No date restriction was defined, and the selected Scopus subject areas were: Business, management and accounting; Computer science; Decision sciences; Economics, econometrics and finance; Energy; Engineering; Environmental science; Psychology; and Social sciences. The resulting output were 819 studies, which were reduced to 140 studies after the

analysis of their titles. This substantial exclusion of studies was due to the multidisciplinary scope of this review. By including journals from diversified subjects, the initial list included studies that were clearly unrelated to this review, such as studies in automotive engineering or studies about choice of transportation mode. The next screening was done through the analysis of the abstracts followed by the full text reading of the remaining 86 studies. As a result, an initial selection of 60 studies was obtained.

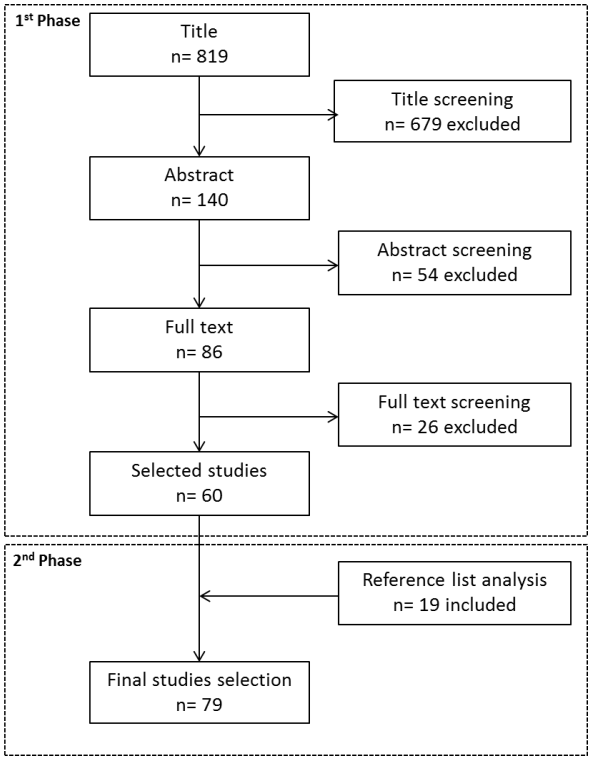

Figure 1. Diagram describing the selection strategy of studies.

The second phase involved an analysis of the references cited by these studies in order to cover all the relevant papers, which resulted in the final selection of 79 studies that are analyzed in the next sections.

4. CM Studies

Understanding consumer preferences has become more complex because consumers have a wide range of choices, such as ICEVs vehicles (gasoline and diesel), BEVs, HEVs, PHEVs, Fuel Cell Vehicles (FCVs), Compressed Natural Gas Vehicles (CNGs), Natural Gas Vehicles (NGVs), and Biofuel vehicles. Therefore, consumers are constantly confronted with huge amounts of information about these vehicles, which is used by them to form preferences and, consequently, to make purchase decisions [34]. This context has been justifying the interest of a substantial body of researchers that developed studies aiming at understanding consumer preferences concerning these vehicles using mainly CM techniques. The use of these techniques allows consumers to state their preference through the comparison of only a few different vehicles at a time.

Table 1 presents the CM studies selected for this review, allowing identification of some trends. First, the number of CM studies has increased significantly in the last six years, with almost three quarters of the studies appearing after 2010. Second, regarding the targeted consumers, North Americans were the most studied, followed by the Europeans. In the first two decades studies were exclusively from North America, but since 2000, European and Asian studies started to be developed (Figure 2). This trend was clearer in the 2010s when the number of European and Asian

studies surpassed the North American. Third, three broad goals of CM studies were identified: to analyze consumer preferences, to forecast the vehicles demand and to develop methodologies for CM. The number of studies aiming at understanding consumer preferences has been markedly increasing relative to forecast studies in recent years (Figure 3). Fourth, the majority of studies were focused on a specific vehicle technology, mainly BEV (55%) or BEV plus other vehicles (36%) (Figure 4). Lastly, considering the vehicles included in the stated preference surveys of CM studies over time, it was observed that the more recent studies compare a more diversified vehicles set than the older studies where only BEVs were compared with ICEVs (Figure 5). Additionally, it was observed that the most common set of vehicles compared were ICEVs, BEVs and HEVs.

Table 1. Consumer preference studies for Alternative Fuel Vehicles (AFVs).

Study	Year	Country	Goal	Scope	Estimation procedure	Sample
Beggs et al. [35]	1981	USA	To assess the potential demand for BEVs	BEVs	Ordered logit model	197 Households
Calfee [36]	1985	USA	To estimate the potential demand for BEVs	BEVs	Disaggregated Multinomial Logit (MNL) models	51 Automobile owners
Bunch et al. [37]	1993	USA	To determine how demand for clean-fuel vehicles is likely to vary as a function of differential attributes	AFVs	Nested MNL models Binomial logit models	717 Households
Golob et al. [38]	1993	USA	To predict the effect on personal vehicle purchases of differential attributes of clean-fuel vehicles	AFVs	MNL model	3000 Households
Brownstone et al. [39]	1996	USA	To construct a vehicle choice model for producing annual forecasts of new and used vehicle demand	BEVs	MNL model	4747 Individuals
Kurani et al. [40]	1996	USA	To examine household consideration of a BEV	BEVs	Statistical analysis	454 Multi-car households
Chéron and Zins [41]	1997	Canada	To determine which are the most determinant factors blocking the purchase of BEVs	BEVs	Statistical analysis	37 Car users
Ewing and Sarigöllü [16]	1998	Canada	To examine the factors likely to influence the demand for lower emission and zero emission vehicles	AFVs	MNL model	811 Suburban driver commuters
Tompkins and Bunch [42]	1998	USA	To perform an independent survey of consumers in US concerning their vehicle preferences and to compare to the preferences of California households	AFVs	Restricted conditional MNL model	1149 Individuals
Kavalec [43]	1999	USA	To investigate the potential effects that an aging “baby boomer” generation will have on gasoline use through their vehicle choice decisions	AFVs	"Mixed" logit error-components model	4552 Households
Brownstone et al. [44]	2000	USA	To compare MNL with mixed logit models for data on California households’ revealed and stated preferences for vehicles	AFVs	Mixed logit models MNL model	7387 Households

Table 1. *Cont.*

Study	Year	Country	Goal	Scope	Estimation procedure	Sample
Ewing and Sarigöllü [45]	2000	Canada	To explore if government regulation can influence consumer preferences for clean-fuel vehicles	AFVs	MNL model	881 Commuters who drive regularly
Dagsvik et al. [46]	2002	Norway	To analyze the potential demand for AFVs	AFVs	Ranked logit model	642 Individuals
Horne et al. [47]	2005	Canada	To analyze how people choose between technologies, and incorporate it into energy-economy models	AFVs	Hybrid model	866 Individuals
Hess et al. [48]	2006	USA	To apply a modified Latin Hypercube Sampling approach for use in the estimation of Mixed MNL models	AFVs	Mixed MNL model	500 Individuals
Potoglou and Kanaroglou [5]	2007	Canada	To examine the factors and incentives that are most likely to influence households' choice for cleaner vehicles	AFVs	Nested logit model	482 Potential vehicle Buyers
Ahn et al. [3]	2008	South Korea	To analyze how adding AFVs to the market will affect patterns in demand for passenger cars	AFVs	Multiple discrete continuous choice model	280 Households who own passenger cars
Bolduc et al. [49]	2008	Canada	To study the application of Hybrid CM about personal choices of vehicles with technological innovations	AFVs	Hybrid choice models	866 Consumers
Mau et al. [50]	2008	Canada	To elicit consumer preferences for HEVs and FCVs with manipulation of the respondents' decision environment	HEVs and FCVs	CIM SMNL model	916 Individuals (HEVs study) 1019 Individuals (FCVs study)
Axsen et al. [51]	2009	Canada and USA	To estimate preference dynamics associated with the adoption of HEVs to improve the behavioral realism of CIMS	HEVs	CIMS MNL model	523 Vehicle owners (Canada) 408 Vehicle owners (USA)
Dagsvik and Liu [52]	2009	China	To specify and estimate models of household demand for conventional gasoline cars and AFVs in Shanghai	AFVs	Generalized Extreme Value random utility model	100 Households
Caulfield et al. [53]	2010	Ireland	To examine individual motivations when purchasing vehicles	AFVs	MNL model Nested Logit model	168 Customers of a car company
Kudoh and Motose [54]	2010	Japan	To understand consumer preferences for BEVs to define their specifications or policies to expand these vehicles	BEVs	Conditional Logit model	1st wave: 6935 Individuals 2nd wave: 9657 Individuals
Eggers and Eggers [55]	2011	Germany	To apply choice-based conjoint to analyse the future acceptance of AFVs	BEVs	Choice-Based Conjoint/Hierarchical Bayes	242 Individual respondents

Table 1. *Cont.*

Study	Year	Country	Goal	Scope	Estimation procedure	Sample
Hensher and Greene [56]	2011	Australia	To apply the random regret minimization model framework to model choice among durable goods	AFVs	MNL	3172 Households who had purchased a vehicle in the last 2 years
Hidrue et al. [6]	2011	USA	To analyze to which extent experience affects preferences and the impact of attitudes on the choice between BEVs and conventional vehicles	BEVs	MNL model Latent class model	3029 Potential car buyers
Mabit and Fosgerau [57]	2011	Denmark	To investigate the potential future of AFVs in Denmark	AFVs	Mixed logit model	2146 New car buyers
Qian and Soopramanien [58]	2011	China	To model consumer preferences for alternative fuel cars and conventional fueled cars	AFVs	MNL model Nested Logit model	527 Households
Senturk et al. [59]	2011	Turkey	To identify the factors that affect the preferences for vehicle fuel types in Turkey	AFVs	MNL model	1983 Participants
Zhang, Gensler, et al. [60]	2011	USA	To investigate which factors can speed the diffusion of AFVs	AFVs	Choice-based conjoint/Hierarchical Bayes	7595 Individuals
Zhang, Yu, et al. [61]	2011	China	To identify the factors that impact consumer preferences for AFVs	BEVs	Binary logistics regression models	229 Respondents from driving schools
Achtnicht et al. [20]	2012	Germany	To study the impact of fuel availability on demand for AFVs	AFVs	Logit model	600 Individuals
Hess et al. [62]	2012	USA	To investigate the prevalence of correlation along two dimensions of choice, vehicle type and fuel type	AFVs	Cross-nested logit model	500 Individuals
Lebeau et al. [63]	2012	Belgium	To examine the market potential of PHEVs and BEVs in Flanders	BEVs and PHEVs	Choice-based conjoint/Hierarchical Bayes	1197 Individuals
Ziegler [21]	2012	Germany	To examine the preferences for alternative energy sources or propulsion technologies in vehicles (mainly BEVs)	BEVs	Multinomial probit models	598 Car buyers
Alvarez-Daziano and Bolduc [64]	2013	Canada	To implement a Bayesian approach to a hybrid choice model in order to analyse choices of Canadian consumers for AFVs	AFVs	Bayesian hybrid choice model	866 individuals (same sample as Horne et al. 2005)
Alvarez-Daziano and Chiew [65]	2013	USA	To study the relevance of the prior in a discrete choice model through the use of Bayes' estimator	BEVs	Bayesian discrete choice model	500 Individuals who were intending to purchase a new car within 3 years
Axsen et al. [66]	2013	United Kingdom	To investigate the roles of social influence in the formation of consumer perceptions and preferences for pro-environmental technologies	BEVs	MNL model	500 Individuals

Table 1. *Cont.*

Study	Year	Country	Goal	Scope	Estimation procedure	Sample
Beck et al. [67]	2013	Australia	To identify how environmental attitudes can influence how consumers behave under an emissions charge policy	AFVs	Latent class model	650 Recent car buyers
Chorus et al. [68]	2013	Netherlands	To compare two discrete choice methodologies, utility maximization and regret minimization model	AFVs	Random regret minimization-based model Random utility maximization model	616 Company car leasers
Hackbarth and Madlener [23]	2013	Germany	To analyze the potential demand for AFVs	AFVs	Mixed logit model	711 Potential buyers of a new car in a short-term
Ito et al. [22]	2013	Japan	To investigate potential demand for infrastructure investment for AFVs	AFVs	Nested MNL model	1531 Individuals
Jensen et al. [69]	2013	Denmark	To analyze to which extent experience affects preferences and the impact of attitudes on the choice between BEVs and conventional vehicles	BEVs	Mixed logit model	369 Households who had bought a car within the last 5 years or at least intended to buy one
Glerum et al. [70]	2014	Switzerland	To present an integrated methodology to forecast the demand for BEVs and to enhance the forecasting power of a model developed on stated preference data	BEVs	Hybrid choice models	593 Recent buyers of a new car (in the last 3 years)
Hoen and Koetse [18]	2014	Netherlands	To get insight into preferences of Dutch private car owners for AFVs and their characteristics	AFVs	MNL model Mixed logit model	1802 Households (market for privately owned cars)
Parsons et al. [71]	2014	USA	To analyze the potential demand for vehicle-to-grid vehicles	BEVs	MNL model Latent Class model	3029 Potential car buyers (same as Hidrue et al. (2011))
Tanaka et al. [24]	2014	USA and Japan	To estimate and compare consumers' willingness to pay for BEVs and PHEVs in US and Japan	AFVs	Mixed logit model	4202 Consumers (USA) 2000 Consumers (Japan)
Axsen et al. [17]	2015	Canada	To characterize heterogeneity in preferences and motivations regarding PHEVs	PHEVs and BEVs	Latent class model	1754 New vehicle buyinghouseholds
Hevelston et al. [72]	2015	USA and China	To identify and compare consumer preferences for BEVs in China and US and to analyze the influence of subsidies in those preferences	BEVs	MNL model Mixed logit model	312 Individuals (US) 572 Individuals (China)
Lieven [73]	2015	20 countries (5 continents)	To analyze the effect of incentives that influence car buyers voluntary behaviour on the adoption of BEVs	BEVs	Choice-Based Conjoint/Hierarchical Bayes	8147 Individual respondents in total (20 countries)
Qian and Soopramanien [74]	2015	China	To forecast the demand of green cars in emerging markets accounting for preference heterogeneity and market dynamics	HEVs and BEVs	Nested logit model	527 Households

Table 1. *Cont.*

Study	Year	Country	Goal	Scope	Estimation procedure	Sample
Shin et al. [19]	2015	South Korea	To assess consumer preferences for various technology options and vehicle fuel types, and to evaluate the marginal willingness-to-pay for various smart vehicle features	AFVs	Multiple Discrete Continuous Probit model Multinomial Probit model	675 Individuals
Valeri and Danielis [75]	2015	Italy	To evaluate the market penetration of cars with AFV technologies in Italy under various scenarios	AFVs	Mixed Error Component Logit model	121 Respondents
Axsen et al. [76]	2016	Canada	To compare the characteristics, preferences, and motivations of pioneers and potential early mainstream buyers	PHEVs	MNL Latent class model	1754 conventional new vehicle buyers 94 Plug EV owners
Bahamonde-birke and Hanappi [77]	2016	Austria	To analyze the acceptance of electric vehicles by the Austrian population	BEVs	Hybrid Discrete Choice model	1449 Individuals
Braz da Silva and Moura [29]	2016	Portugal	To estimate the fleet wide energy consumption and corresponding CO_2 emissions up to 2030	BEVs and PHEVs	Nested Logit model	348 Respondents
Hackbarth and Madlener [78]	2016	Germany	To study the heterogeneity of car buyers' preferences	AFVs	MNL model Latent Class model	711 (same as Hackbarth and Madlener (2013))
Krause et al. [79]	2016	USA	To assess how consumer demand might change with various breakthroughs in PHEVs technology	PHEVs	MNL model	961 Potential new vehicle purchasers
Rudolph [80]	2016	Germany	To investigate the impact of five different incentives for buyers of zero emission vehicles	BEVs	Mixed Logit model	875 Respondents
Beck et al. [81]	2017	Australia	To examine attributes in a best–worst scaling framework	BEVs, PHEVs and HEVs	Rank-ordered logit model	204 Respondents
Cherchi [82]	2017	Denmark	To measure the effect of both informational and normative conformity in the preference for EVs versus ICEVs	BEVs	Mixed logit model	2363 respondents
Cirillo et al. [83]	2017	USA	To analyze household future preferences for gasoline, HEVs and BEVs in a dynamic marketplace	BEVs and HEVs	Mixed MNL model	456 Respondents
Dimatulac and Maoh [84]	2017	Canada	To study the determinants that led to the observed spatial distribution of HEVs vehicles	HEVs	MNL model	348 HEVs owners
Higgins et al. [85]	2017	Canada	To examine how preferences for HEVs, PHEVs and BEVs are shaped by vehicle body size or type	HEVs, PHEVs and BEVs	Multivariate analysis of variance and probit model	15,392 households

Table 1. *Cont.*

Study	Year	Country	Goal	Scope	Estimation procedure	Sample
Jensen et al. [86]	2017	Denmark	To discuss the prediction of EVs market shares and to suggest a method combining a diffusion model with advanced discrete choice models	BEVs	Mixed Logit model	196 Respondents
Liu and Cirillo [87]	2017	USA	To propose a generalized dynamic discrete choice approach that models purchase behavior and forecasts future preferences	EVs	MNL model	456 Maryland households
Ma et al. [88]	2017	China	To investigate the potential impact of purchase subsidies and charging facilities on demand for EVs	BEVs	MNL model	465 Respondents
Sheldon et al. [26]	2017	USA	To estimate demand for PHEVs relative to BEVs and to explore heterogeneity in demand for these vehicles	BEVs and PHEVs	Mixed logit model Latent class model	1261 New car buyers
Smith et al. [89]	2017	Australia	To investigate consumer preferences and attitudes towards EVs	BEVs	Nested logit model	440 households
Byun et al. [90]	2018	South Korea	To analyze consumer preferences for vehicles and predict the dynamic market share of environmentally friendly vehicles	BEVs and FCVs	Mixed Logit model	615 Adult respondents
Choi et al. [91]	2018	South Korea	To analyze how the consumer adoption of BEVs and their environmental impact can be changed by improving the environmental performance of the electricity generation mix	BEVs	Mixed Logit model	1002 Respondents
Costa et al. [92]	2018	Italy	To investigate consumers' willingness to pay a premium price for lower CO_2 emitting cars	AFVs	Conditional MNL model	278 Potential car buyers
Ferguson et al. [93]	2018	Canada	To assess attitudes and preferences towards consumer electric vehicles	HEVs, PHEVs and BEVs	Latent class choice model	17,953 households
Hahn et al. [94]	2018	South Korea	To understand consumers' preferences for green vehicles	HEVs, PHEVs and BEVs	Mixed model and nested logit model	4548 consumers
Huang and Qian [25]	2018	China	To investigate consumer preferences for EVs in lower tier cities of China	BEVs and PHEVs	Nested Logit model	348 Respondents
Liao et al. [95]	2018	Netherlands	To assess the impact of business models, in particular battery and vehicle leasing, on EVs adoption	BEVs and PHEVs	Latent Class Choice model	1003 Respondents

Table 1. *Cont.*

Study	Year	Country	Goal	Scope	Estimation procedure	Sample
Liu and Cirillo [96]	2018	USA	To forecast households' future preferences on vehicle type, quantity and use, and to estimate greenhouse gas emissions	EVs	Multinomial probit model	456 Maryland households
Soto et al. [97]	2018	Canada	To evaluate the influence of policies, attitudes and perceptions when incentivizing AFVs	AFVs	Hybrid choice models	1065 Respondents
Wolbertus et al. [98]	2018	Netherlands	To estimate the effect of policy measures aimed at EV adoption and charging behavior	HEVs, PHEVs and BEVs	Mixed logit model	149 respondents

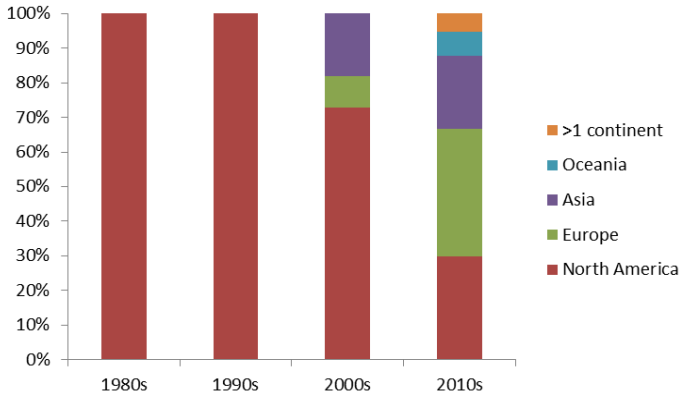

Figure 2. Choice Modelling (CM) studies per continent.

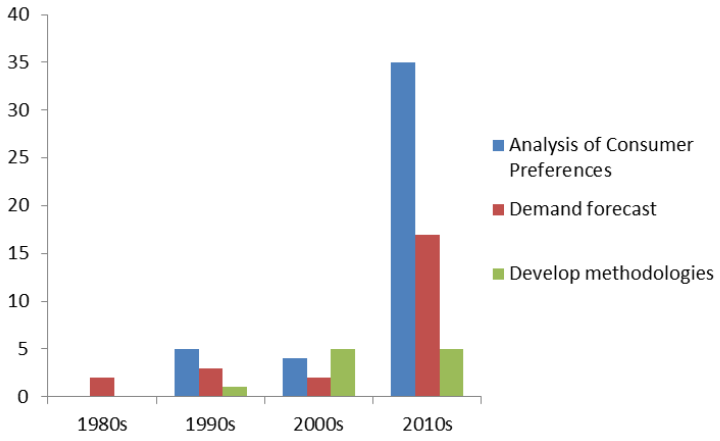

Figure 3. Goals of CM studies evolving with time.

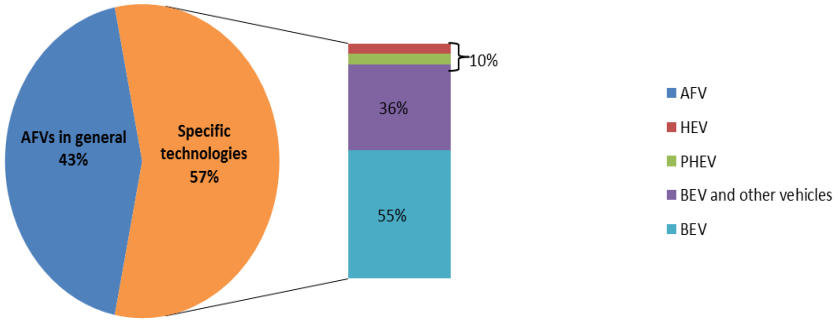

Figure 4. CM studies by scope.

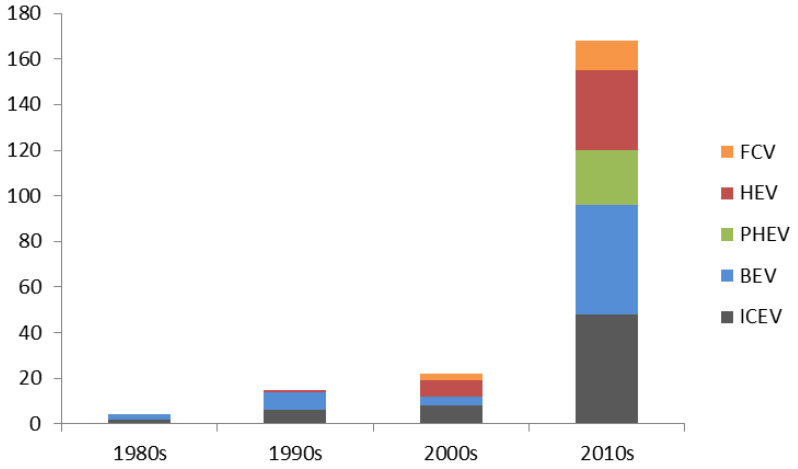

Figure 5. Vehicles included in the CM studies.

5. Individual Characteristics of Consumers

AFVs are innovative and marketed as environmentally friendlier products. Therefore, these two dimensions of consumer behavior need to be addressed in order to understand what drives consumers' preferences for these vehicles. Several studies focused on which consumers would prefer environmental or innovative products. Consumer profiling for environmentally friendly products began in the 1970s [99] and was followed by studies attempting to identify which consumer specific characteristics could be related to the consumption of ecological products [99,100]. Regarding the innovative dimension, an extensive literature has analyzed the consumer behavior about innovative products trying to understand the influence of personal characteristics on the adoption of innovative products [101]. As the influence of consumers' characteristics on their preferences/behavior does not affect equally all the innovative and/or environmentally friendly products, this review aims to understand what are the trends, if any, of consumer personal characteristics are connected to preferences for AFVs.

Demographic variables are frequently and extensively analyzed in all consumer-based research [101] and have been considered one of the major influences on vehicle demand [30]. The list of demographic characteristics that can influence consumer preferences is extensive. Therefore, for this analysis, the selection of individual characteristics was based on the relevant characteristics for innovative and environmental products found in previous studies. Laroche et al. [99] present the demographic characteristics that can influence purchases of environmentally friendly products namely, age, gender, income, level of education, employment status, home ownership, marital status and family size. Concerning the adoption of innovative products, Kaushik and Rahman [101] through an extensive literature review about consumer innovativeness, identified age, income, education, gender, sexual orientation, religion and family size as the most common characteristics related to consumer

preferences. In order to analyze their influence on consumer preferences for AFVs, age, gender, income, level of education and family size were selected, which are common to the lists of Laroche et al. [99] and Kaushik and Rahman [101]. Moreover, two vehicle-related demographics were added, driving habits and number of vehicles owned per household, due to their relevance and frequent analysis in AFVs studies.

Table 2 comprises the studies that collected consumer characteristics and presents the purpose of each study on collecting such data for consumer preferences analysis. Most of the studies collected consumer characteristics data (92%) where the most analyzed characteristic is age, followed by gender and income. Regarding the purpose of collecting such data, the main reasons identified were the analysis of sample representativity (52%), analysis of the interaction of individual characteristics with vehicle preferences (41%) and with vehicle attributes (15%) (Figure 6). Only one study (Mabit and Fosgerau [57]) covered these three analyses. It can be highlighted that 27% of the studies collected demographic data exclusively to analyze if the sample was representative.

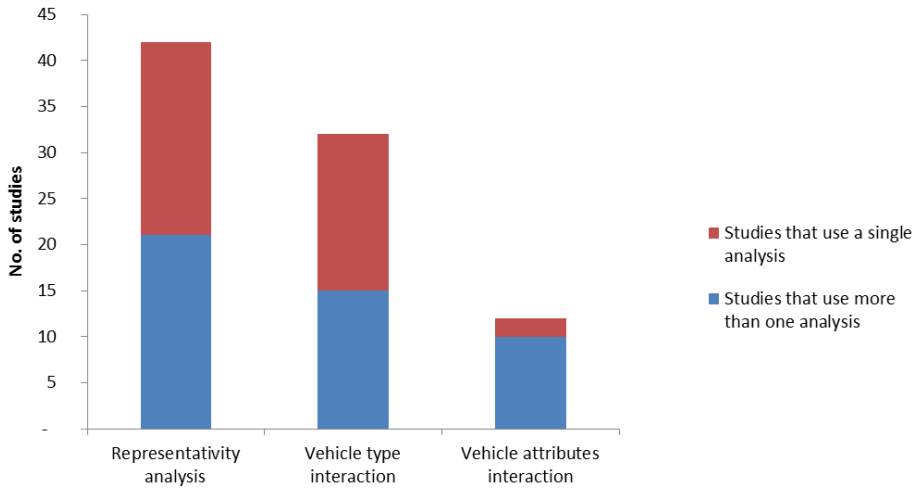

Figure 6. Purpose of collecting demographic data.

Table 2. Demographic characteristics analyzed in consumer preference studies (NM: Not Mentioned).

Study	Demographic Variables Collected								Demographic Data Collected to Analyze		
	Age	Gender	Income	Education	Family Size	No. Vehicles/Family	Driving Habits	Other	Representativity	Vehicle Type Interaction	Vehicle Attributes Interaction
Beggs et al. [35]	✓	✓	✓	✓	✓					✓	
Bunch et al. [37]	✓	✓	✓	✓	✓					✓	
Golob et al. [38]		✓			✓	✓		home ownership status, no. of drivers		✓	
Brownstone et al. [39]	✓		✓		✓	✓					
Ewing and Sarigöllü [16]	✓	✓	✓			✓	✓	home language, ownership status			
Kurani et al. [40]							NM				
Chéron and Zins [41]							NM				
Tompkins and Bunch [42]	✓	✓	✓	✓	✓	✓			✓		vehicle body type, vehicle size
Kavalec [43]	✓				✓		✓		✓		
Brownstone et al. [44]	✓		✓	✓	✓					✓	
Ewing and Sarigöllü [45]	✓		✓						✓		
Dagsvik et al. [46]	✓	✓								✓	price, top speed, range, fuel consumption
Horne et al. [47]	✓	✓	✓	✓				region, vehicle type, commuting habits	✓		
Potoglou and Kanaroglou [5]	✓	✓	✓	✓		✓				✓	acceleration, price
Bolduc et al. [49]	✓	✓	✓	✓				mode of transportation			
Mau et al. [50]	✓		✓		✓				✓		
Axsen et al. [51]	✓	✓	✓	✓				house location	✓		
Dagsvik and Liu [52]	✓	✓	✓		✓						
Caulfield et al. [53]	✓	✓	✓	✓					✓	✓	
Kudoh and Motose [54]	✓	✓							✓		
Eggers and Eggers [55]	✓	✓						current car	✓		
Hensher and Greene [56]	✓	✓	✓								price, fuel consumption, engine capacity, seating capacity
Hidrue et al. [6]	✓	✓	✓	✓		✓	✓	type of residence	✓	✓	
Mabit and Fosgerau [57]	✓	✓	✓		✓				✓	✓	acceleration, range, price
Qian and Soopramanien [58]	✓		✓		✓	✓	✓	average distance from home to workplace, no. of working members		✓	
Senturk et al. [59]	✓	✓	✓	✓		✓	✓			✓	

Table 2. *Cont.*

Study	Demographic Variables Collected								Demographic Data Collected to Analyze		
	Age	Gender	Income	Education	Family Size	No. Vehicles/Family	Driving Habits	Other	Representativity	Vehicle Type Interaction	Vehicle Attributes Interaction
Zhang, Yu, et al. [61]	✓	✓	✓	✓	✓	✓		no. family members with driver license		✓	
Achtnicht et al. [20]	✓	✓	✓	✓					✓		
Hess et al. [48]			✓		✓	✓		house location, no. of workers	✓		
Lebeau et al. [63]	✓	✓		✓				region	✓		
Ziegler [21]	✓	✓		✓	✓	✓	✓	habitation location		✓	
Alvarez-Daziano and Bolduc [64]	✓	✓	✓	✓				mode of transportation to commute		✓	
Axsen et al. [66]	✓		✓	✓	✓						
Beck et al. [67]	✓	✓	✓		✓		✓	employment status, no. of hours worked, driver's license years			
Hackbarth and Madlener [23]	✓		✓	✓			✓	home ownership status	✓	✓	
Ito et al. [22]	✓	✓	✓			✓			✓		vehicle size
Jensen et al. [69]	✓	✓				✓				✓	
Glerum et al. [70]	✓	✓			✓			language	✓		
Hoen and Koetse [18]	✓	✓		✓	✓		✓	possibility of home, current vehicle type	✓		price
Parsons et al. [71]	✓	✓	✓	✓		✓					
Tanaka et al. [24]	✓	✓	✓	✓				marital status, house dwelling, AFVs interest	✓	✓	
Axsen et al. [17]	✓	✓	✓	✓				residence type, PHEVs familiarity	✓		
Hevelston et al. [72]	✓	✓	✓	✓	✓		✓	marital status, access to vehicle charging	✓		
Lieven [73]	✓	✓					✓		✓		range
Qian and Soopramanien [74]	✓	✓	✓		✓	✓		distance home to work, no. of working members	✓	✓	
Shin et al. [19]	✓	✓	✓		✓		✓	dwelling size		✓	
Valeri and Danielis [75]		✓	✓	✓					✓		price, acceleration, range, annual operating cost
Axsen et al. [76]	✓		✓		✓				✓		

Table 2. *Cont.*

Study	Demographic Variables Collected								Demographic Data Collected to Analyze		
	Age	Gender	Income	Education	Family Size	No. Vehicles/Family	Driving Habits	Other	Representativity	Vehicle Type Interaction	Vehicle Attributes Interaction
Bahamonde-birke and Hanappi [77]	✓	✓	✓					marital status	✓		engine size
Braz da Silva and Moura [29]	✓	✓	✓	✓	✓		✓	region and employment status	✓		
Hackbarth and Madlener [78]	✓	✓	✓	✓	✓	✓			✓	✓	
Krause et al. [79]		✓		✓	✓			Race	✓	✓	
Rudolph [80]	✓	✓	✓	✓				type of employment	✓		
Beck et al. [81]	✓	✓	✓		✓				✓	✓	
Cherchi [82]	✓	✓	✓		✓	✓	✓	Job			charging time, fuel/electricity cost
Cirillo et al. [83]	✓	✓	✓	✓				work status, home type	✓	✓	
Dimatulac and Maoh [84]		✓	✓	✓				type of occupation		✓	
Higgins et al. [85]	✓	✓	✓	✓	✓			language, marital status, dwelling type, dwelling tenure	✓		vehicle size, vehicle body
Jensen et al. [86]	✓	✓	✓		✓	✓	✓	no. children	✓		
Liu and Cirillo [87]	✓	✓	✓	✓					✓	✓	
Ma et al. [88]	✓	✓	✓			✓		region	✓	✓	
Sheldon et al. [26]	✓		✓	✓	✓	✓				✓	
Smith et al. [89]	✓		✓	✓		✓				✓	
Byun et al. [90]									✓		
Choi et al. [91]	✓	✓	✓						✓		
Costa et al. [92]	✓	✓		✓					✓		
Ferguson et al. [93]	✓	✓	✓	✓	✓			marital status, dwelling type, dwelling tenure	✓	✓	
Hahn et al. [94]	✓	✓	✓		✓			driving experience, housing type, occupation		✓	
Huang and Qian [25]	✓	✓	✓	✓	✓	✓		no. children, car use experience		✓	
Liao et al. [95]	✓	✓	✓	✓	✓	✓				✓	
Liu and Cirillo [96]	✓	✓	✓	✓					✓		
Soto et al. [97]	✓	✓		✓	✓	✓				✓	
Wolbertus et al. [98]	✓	✓	✓	✓		✓		full employment	✓	✓	

5.1. Sample Size and Representativity

The results from the selected studies can be compared in order to find relevant conclusions. However, as the group of studies differ regarding the sample characteristics, a complementary analysis of the samples size and representativity was done in order to enhance the comparability of the results. This analysis comprised only the studies that collected consumer demographics data (Table 2).

Regarding the sample size, all the studies to be compared should have a sample size large enough to allow the drawing of reliable conclusions from the involved choice tasks. For each study, the minimum sample size, n, was computed using a standard computation through an expression adapted from [102], $n \geq 500\frac{c}{ta}$, where t is the number of choice tasks that each consumer has to answer, a is the number of alternatives per choice task and c is the largest number of levels for any one attribute. The analysis allowed verifying that all the studies fulfilled this requirement. In consumer preference studies for AFVs the sample representativity is not usually set as a goal. This is mainly due to the use of convenience samples (used in 65% of the analyzed studies), i.e., most studies select consumers that meet specific requirements such as consumers that intend to purchase a vehicle in the next five years, which usually occurs at the cost of not getting representative samples of the targeted population. A low number of studies that aimed to have representative samples was found (53%) (see Figure 6) from which only 38% achieved samples that would represent the targeted markets. These findings support that sample representativity is not a priority in these types of studies, and for that reason is not an obstacle to the comparison of studies, although keeping in mind that these may not represent accurately the entire population of a country.

5.2. Relation between Consumer Preferences for Vehicle Type and Demographic Data

In order to understand the direction in which the consumer characteristics influence consumer preferences for AFVs, several hypotheses were formulated based on what was found in the literature regarding the purchase behavior of consumers for sustainable and innovative products in general. Below we present these hypotheses and discuss whether the conclusions of studies focused on AFVs support them.

5.2.1. Age Influence

The effort to understand consumer preferences, and consequent behavior, of the market segments defined by the consumers age is very common [103]. The relationship between age and the adoption of new environmental friendly products has motivated several studies pointing out that it is expected that younger consumers have higher preferences for innovative and/or environmentally friendly products for several reasons: younger consumers have higher propensity to try and adopt novel products, they are more likely to choose products that imply considerable changes to their daily routines and to take risks than older consumers [104]; consumers that grow up in a time period with higher environmental concerns are more sensitive to ecological issues and related products [100]; older consumers will try a new product only if they find that product will satisfy a specific need they have, not just because it is trendy [105]. These considerations led to the development of the following hypothesis:

H1. *Younger consumers have higher preferences for AFVs.*

Regarding BEVs, several studies concluded that younger consumers preferred these vehicles more [6,21,23,26,46,71,83,95] or that older consumers have lower preferences for BEVs or prejudice against these vehicles [20,37,77]. On the other hand, some studies concluded that older consumers are more likely to purchase BEVs [19,61], possibly because they can afford the higher initial cost to buy these vehicles and are less concerned about the limited range [19,61]. Focused on FCVs, Ziegler [21] found that younger consumers have higher propensity to choose these vehicles. Concerning HEVs, Senturk et al. [59] reported that older consumers prefer these vehicles over gasoline vehicles, which can be justified by their higher sensitivity to the factors that affect negatively their health, whereas Hackbarth and Madlener [23] found that younger consumers are more likely to adopt HEVs. Additionally, there

were studies that analyzed the effect of age on AFVs in general: one concluded that preferences for these vehicles increase with age [53] whereas others concluded that age affects negatively the preferences for AFVs [5,16,58,78].

Since the results regarding the hypothesis H1 were inconclusive it was decided to seek other explanations. Cultural differences can lead to variations of consumers level of innovativeness [106]; for instance, North American consumers have reportedly higher propensity for innovative products than consumers from Asian countries [107]. In this context, the following hypothesis was analyzed in order to unveil a potential explanation for the identified contrasts:

H2. *The influence of age on consumer preferences for AFVs varies across geographical regions.*

Studies developed in North America [5,6,16,26,37,44,83,87] and Europe [21,23,46,77,78,95] reported that younger consumers are more willing to buy greener vehicles (with the exception of [53]). On the other hand, Asian studies, with the exception of [58], found that older consumers have higher propensity to buy AFVs [19,59,61,88]. Therefore, the summarized results are consistent with hypothesis H2.

5.2.2. Gender Influence

Consumer behavior varies according to gender, which is mainly justified by role differences in cultural and social contexts [108]. A significant impact of gender in the consumption of sustainable products [109] and innovative products [108] has been observed.

In general, women are more likely to have higher preferences than men for sustainable products, due to their stronger attitudes, values and consciousness towards the environment [64,109]. Regarding innovative products the gender influence is more context-dependent because it is highly dependent on the type of product. Since the gender effect on preferences for AFVs is not easily anticipated we analyzed the following hypothesis:

H3. *Men have higher preferences for AFVs.*

Regarding BEVs, while several studies found that men preferred these vehicles less than women [46,57,79,83,88,95], there was only one study that concluded that men preferred BEVs [87]. On the other hand, there were two studies where no interaction between gender and BEVs preferences was found [21,61]. The studies of Mabit and Fosgerau [57] and Ziegler [21] differ on their results about FCVs: the first found that men have lower preferences for FCVs than women while the second concluded the opposite. Concerning HEVs, several studies found that it is less likely that men will purchase these vehicles [53,74,87,93]. Considering AFVs in general, Qian and Soopramanien [58] observed that men are not keen to adopt a green vehicle.

Summing up, with the exception Ziegler [21] and Liu and Cirillo [87], the results of previous studies do not support the defined hypothesis by revealing that women are more willing than men to follow and prefer sustainable vehicles. These results can be explained by the different ways that women and men face the technical limitations of AFVs, as women are less sensitive to limited range [37] and men have more concerns about the driving range and fueling infrastructure for BEVs in the short-term [46].

5.2.3. Income Influence

Income is considered a strong predictor of the adoption of innovative products even though no influence between income and consumer innovative behavior has been reported in some studies [34,110]. The main argument is that for innovative consumers to try and buy new products, a minimum level of income is needed [111]. Therefore, income is expected to relate positively with new products by decreasing the resistance to their higher price [106]. Additionally, high income consumers are likely to be more environmentally conscious because consumers with higher income can bear more

easily the higher costs arising from adopting ecological products [100]. In this context, the following hypothesis was analyzed:

H4. *Wealthy consumers have higher preferences for AFVs.*

High levels of income are commonly assumed to be related to high levels of education [61]. It is thus expected that wealthy consumers are better informed about the advantages of AFVs and are more likely to prefer them [19,52,59], by valuating more their operation cost savings [72]. However, this relation cannot be generalized to all AFVs, due to the presence of contradictory results in the studies reviewed. Some studies concluded that consumers with higher income present higher preferences for BEVs [19,24,61] but another study concluded that consumers with higher earnings are more opposed to BEVs [72,83]. Hidrue et al. [6] and Ferguson et al. [93] concluded that income did not influence consumers' choice for BEVs. Regarding HEVs, on one hand some studies concluded that wealthy consumers have stronger preferences for these vehicles [5,53,58,83,97] whereas others found that consumers who earn more have lower intentions to adopt HEVs [19,72] or that consumers with lower income prefer HEV [94]. Bunch et al. [37] reported that as consumer income increases the level of environmental concerns decrease and, for that reason, preferences for gasoline vehicles are higher.

In summary, regarding the influence of income on consumer preferences for AFVs no trend can be found so far as no consensus has been verified regarding the studied vehicle technologies, which leads us to inconclusive results regarding hypothesis H4.

5.2.4. Level of Education Influence

It is expected that education positively affects the adoption of innovative products, because it gives consumers a broader perspective and renders them more into new ideas and products [106]. There are studies where education was found to have no influence on innovative behavior [110,112] and studies where education was found to affect positively consumer innovative behavior [106,111]. Regarding environmental products, several studies found a positive link between higher education and environmental concerns [100,113], and, when only individuals with the same environmental concerns are considered, those who are more educated may present higher awareness regarding the external effects of their consumption behavior and higher concerns about social welfare [113]. This background led us to analyze the following hypothesis:

H5. *Highly educated consumers have higher preferences for AFVs.*

Concerning AFVs, it was found that environmental concerns increase according to level of education [49,64]. Almost all the reviewed studies are consistent in their findings regardless of the type of vehicle analyzed: consumers with a higher level of education are more likely to prefer and buy BEVs [6,23,24,37,44,79,93,97]; HEVs [5] and PHEVs [23,24]. In line with these findings, Sheldon et al. [26] and Huang and Qian [25] found that less educated consumers have less preference for BEV and PHEV. Zhang et al. [61] is the only study presenting contrary results by finding that well-educated consumers are unwilling to buy BEVs in the short-term. A possible explanation pointed out in this study is that the less developed sector of electric vehicle industry in China leads to consumers with higher knowledge levels to be more familiar with the disadvantages of these vehicles and consequently do not purchase them in the short-term.

In summary, it can be concluded that results from previous studies support hypothesis H5.

5.2.5. Family Size Influence

The influence of the number of family members on the purchase of innovative products is expected to be negative because parents' attention is more focused inward rather than outward to innovations [106]. On the other hand, families who have children are more willing to pay more for environmental products due to their concerns about the negative impact of a ruined environment on their children's future [99]. Therefore, the impact of the family size on environmentally friendly

vehicles preferences it is not easily predictable. In order to understand what the relation between family size and AFVs purchase behavior is, the following hypothesis was formulated:

H6. *Consumers with larger families have higher preferences for AFVs.*

The literature reveals that studies addressing the influence of the number of family members in the preferences for EVs reached the same conclusion: larger families are more willing to purchase BEVs [25,39,58,61,74,79] or a PHEV [25,26]. This is in line with hypothesis H6. These findings suggest that perceived environmental benefits of purchasing a more sustainable vehicle may be significant for larger families.

5.2.6. Vehicle-Related Demographics Influence

Two vehicle-related demographics influences were analyzed, driving habits and number of vehicles owned per household.

Driving habits are mainly expressed by the average vehicle mileage driven annually, weekly or daily [18,19,43,59,67,72] or by the type of route that consumers use more often, city or intercity routes [5,23,58]. On one hand, the influence of driving habits on preferences for AFVs may favor AFVs over diesel or gasoline vehicles as the running costs of AFVs are usually lower. On the other hand, it may influence consumers to not prefer AFVs as the owners of these vehicles face more often limited range and fuel availability problems [18]. Therefore, we analyzed the following hypothesis:

H7. *Short-distance travelers have higher preferences for AFVs.*

Two studies concluded that consumers that drive long distances present lower preferences for AFVs which was justified by their limited range and the limited availability of fuel that may compromise charging or refueling these vehicles [5,58]. On the other hand, Dimatulac and Maoh [84] found that long-distance consumers are more likely to purchase HEVs in order to save on the price of gas. Considering consumers that undertake mainly city routes, Hackbarth and Madlener [23] concluded that these consumers are more willing to buy BEVs due to the suitable range of these vehicles for city journeys. In this sense, the results tend to support hypothesis H7 in that the influence of driving habits on preferences for AFVs is highly related to the technical limitations of these vehicles. However, as manufacturers are continuously trying to overcome these limitations the influence of driving habits on consumer preferences may decrease over time.

The number of vehicles owned per household is expected to positively affect the willingness to buy AFVs because these vehicles are considered to be fuel efficient [59] and also because households with more than one vehicle can manage the limitations of some AFVs. The low range of BEVs, for instance, is less of a concern as they have other vehicles for their long-distance journeys. In this context, the following hypothesis was analyzed:

H8. *Consumers with more than one vehicle have higher preferences for AFVs.*

Some studies concluded that families that own more vehicles are more willing to buy a BEV [61] or a biofuel vehicle [21]. One explanation pointed out for these results is the assumption that households that own more vehicles are wealthier and for that reason can more easily afford the higher purchase price of AFVs [61] (although we found inconclusive results concerning Hypothesis H4). On the other hand, Senturk et al. concluded that households with more vehicles present lower preferences for HEVs [59]. Therefore, the results show that the influence of the number of vehicles might be dependent on the type of vehicle or may be related to the families' wealth and for that reason the results regarding hypothesis H8 are inconclusive.

5.3. Relation between Consumer Preferences for Vehicle Attributes and Demographic Data

The vehicle attributes analyzed more often were purchase price, range, fuel consumption and acceleration (Figure 7), whilst the influence of age and gender on preferences was tested with greater

frequency. However, very few studies found a statistically significant influence of demographics on preferences for vehicle attributes.

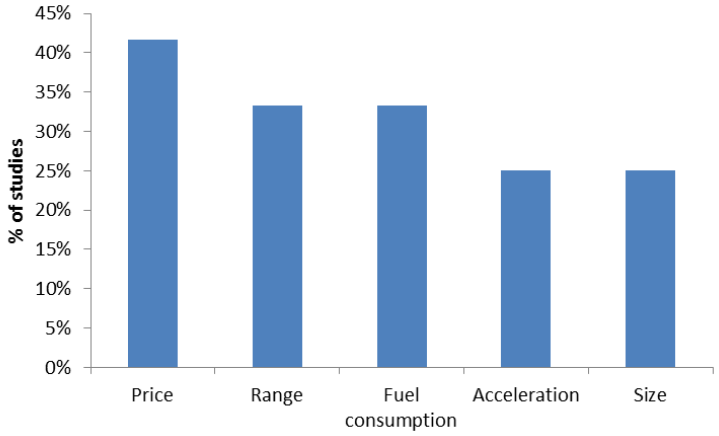

Figure 7. Frequency of vehicle attributes analyzed more often.

Regarding the influence of gender and age on preferences for range previous studies found that women [16,73] and younger consumers [16,57] are more sensitive to range. On the other hand, [75] concluded that women are less sensitive to range. Additionally, women were also found to be less sensitive to purchase price [75], acceleration [5,16,75], fuel consumption [75] and top speed [46] than men. Concerning the vehicle size, women and younger consumers have higher preferences for midsize vehicles, while men and older consumers prefer large vehicles [22,42].

6. The Portuguese Case

This new study was developed in Portugal in order to collect and analyze the consumer preferences for AFVs. The Portuguese government targeted a 5% share of AFVs in 2020 [114], but the efforts put in place to successfully mass introduce these vehicles in the market have not been as effective as expected. Most of the incentives from the government and suppliers took place between 2010 and 2012, but this coincided with the financial crisis in Portugal, when the transport sector faced a sharp decrease of LDVs sales (Figure 8).

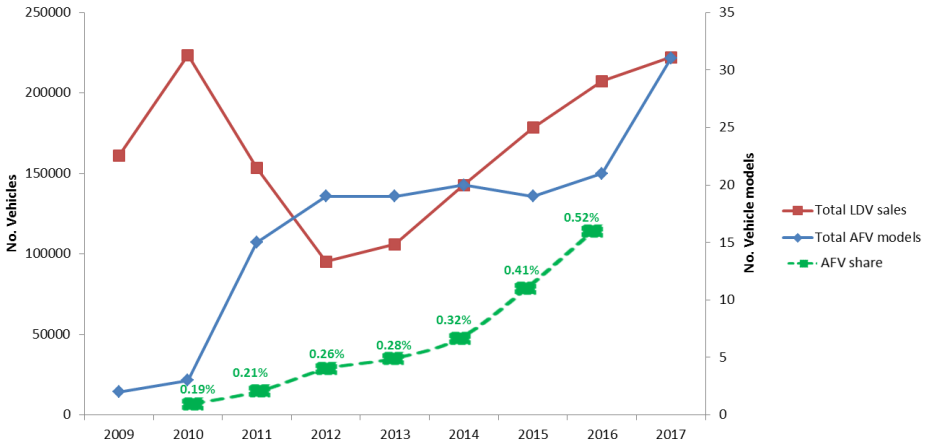

Figure 8. Evolution of Light Duty Vehicles (LDVs) sales with AFVs models introduction and the achieved AFVs share.

Additionally, crossing the timing of the government incentives (consulted in www.dre.pt (electronic Diary of Republic)) for EVs penetration and the evolution of sales shows that that the

sales dynamics did not respond to the incentives as would be expected; in fact, in some periods of time they behaved in the opposite direction (Figure 9). For instance, plug-in electric vehicles (BEVs and PHEVs) demand increased steeply in 2012 and in 2016 after the purchase subsidy and the ICEVs discards incentives decreased, respectively.

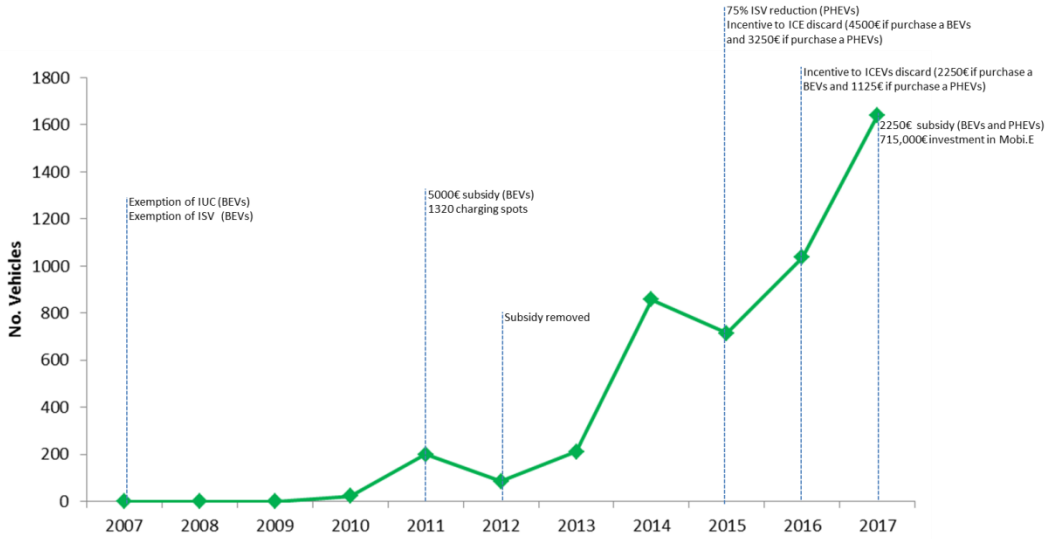

Figure 9. Sales of plug-in electric vehicles crossed with Portuguese government incentives for electric mobility (IUC = circulation tax; ISV = vehicle purchase tax).

This context of AFVs market dynamics in Portugal along with the absence of studies analyzing the influence of demographics on Portuguese consumer preferences brings relevance to develop a study in this market under the scope of the review previously presented, i.e., aiming at analyzing Portuguese consumer preferences for AFVs that collected data through a stated preference survey elicited through CM methods.

The selection of alternatives in this stated preference survey includes all the main AFVs currently available in the Portuguese market, namely BEVs, PHEVs and HEVs. For comparison purposes two ICEVs vehicles were also included, namely Diesel and Gasoline vehicles. Regarding the attributes selection and according to a previous study, purchase price, fuel consumption, range and CO_2 emissions, in this order, are the most relevant characteristics for consumers when differentiating similar vehicles with different powertrains [115]. The type of engine was added to this list of attributes in order to distinguish the vehicle technology of each alternative. The attributes are defined as follows:

- Purchase price: cost to acquire a vehicle, measured in €;
- Range: distance that can be driven without fueling/charging the vehicle, measured in km;
- Fuel consumption: cost to drive 100 km, measured in €/100 km;
- CO_2 emissions: quantity of CO_2 emissions released to the environment during the usage phase of the vehicle, measured in g/km.

Two tasks were included in the survey. One task consisted in collecting data about consumers' characteristics and their vehicles, namely age, gender, level of education, current vehicle, main route, number of kilometers driven per year and knowledge about EVs. The other task comprised a set of Choice-Based Conjoint Analysis (CBC) rank-order questions where consumers were asked to choose the preferred and the least preferred alternative among a set of three. Previous to the design of CBC questions a set of levels was defined for each attribute (Table 3). The CBC questions were obtained through a fractional factorial experimental design, which combined all these attribute levels using Sawtooth® software (Sawooth Software, Utah, UT, USA). As a result, eight versions of nine questions each were obtained that were randomly assigned to each consumer (105 respondents).

Table 3. Levels for each attribute.

Attribute **Type of Engine**	*Levels* **BEV/PHEV/HEV/Diesel/Gasoline**
Price	24,000 €/27,000 €/30,000 €/32,000 €/34,000 €
Range	150 km/250 km/350 km/900 km/1200 km
Fuel/electricity costs (per 100 km)	2 €/4 €/6 €/8 €/10 €
CO_2 emissions (per km)	50 g/90 g/110 g/130 g/150 g

The sample was drawn on a convenience basis allowing to gather data from a group of consumers with more interesting characteristics for the study purposes. The use of a convenience sample gives an exploratory nature to this work that aims to provide insights about the influence of demographics on Portuguese preferences for AFVs and not to be representative of Portuguese consumers. Two selection criteria were applied: consumers should be older than 18 years old and should be potential vehicle buyers in the short-medium term. Data was collected through face-to-face interviews where the SP surveys were presented for each consumer individually.

6.1. Analysis of Sample Representativity

According to Statistics Portugal from Census 2011 [116], the sample used is not representative of Portuguese population, as young adults, men and consumers with higher education are overrepresented (Table 4). The misrepresentation of Portuguese population is a downside of selecting a convenience sample that fits the selection criteria for the study. However, as previously mentioned, the absence of representativity is not a major concern if it allows gathering data from a group of consumers with more interesting characteristics for the purposes of the study.

Table 4. Demographics of consumers.

Variable	Sample (%)	INE (2011 National statistics) (%)
Age		
<45	61	43
≥45	39	57
Gender		
Women	44	53
Men	56	47
Level of education		
No higher education	27	84
College degree	40	13
Master/PhD degree	33	3

6.2. Analysis of the Interaction of Demographic Data with Vehicle Type and Attributes

The analysis of interactions was made through counting analysis, namely through a "Between group Chi-Square" test. This test consists in identifying if the levels of one attribute significantly differ in their choice frequency between demographic groups, for example if women are more likely to prefer a BEV than men.

The counting analysis results are depicted on Tables 5 and 6, along with the respective Chi-Square results. Considering only the results that were found to be statistically significant for the "Between group Chi-Square" test, some conclusions could be derived. According to the results, preferences for the type of engine are frequently influenced by demographic characteristics of consumers. BEVs are more likely to be preferred by older consumers, similar to Zhang, Yu, et al. [61] and Shin et al. [19]; by consumers that drive less annually and by city drivers, in line with Hackbarth and Madlener [23]. On other hand, younger consumers, drivers of intercity routes and consumers that drive less have higher preferences for gasoline vehicles. In line with findings in Dimatulac and Maoh [84], consumers that drive long-distances more often have higher preferences for HEVs.

Table 5. Counting analysis for each consumer characteristics.

Demographic variables												
	Age			Gender			Level of education					
Attribute	<45	≥45	Dif.	M	F	Dif.	No higher education	College degree	Master/PhD degree			
Type of engine												
BEV	19%	25%	−6%	22%	20%	+2%	23%	22%	17%			
PHEV	40%	44%	−4%	42%	40%	+2%	46%	42%	35%			
HEV	40%	38%	+3%	40%	38%	+2%	35%	36%	49%			
Gasoline	33%	18%	+15%	24%	33%	−9%	18%	31%	33%			
Diesel	49%	46%	+3%	48%	49%	−1%	50%	46%	50%			
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	0.01			
Sig. between groups			0.05			Not Sig.						Not Sig.
Price												
24,000	45%	38%	+7%	41%	45%	−4%	40%	42%	49%			
27,000	50%	49%	+1%	50%	50%	0%	46%	47%	59%			
30,000	28%	28%	−1%	29%	27%	+3%	29%	30%	24%			
32,000	25%	23%	+1%	26%	22%	+4%	21%	25%	26%			
34,000	17%	22%	−5%	18%	19%	−1%	26%	20%	9%			
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	0.01			
Sig. between groups			Not Sig.			Not Sig.						0.05
Range												
150	15%	19%	−3%	17%	16%	+2%	20%	17%	13%			
250	21%	28%	−7%	25%	22%	+2%	27%	25%	19%			
350	20%	32%	−12%	25%	24%	+1%	25%	26%	20%			
900	35%	28%	+7%	34%	32%	+1%	30%	33%	35%			
1200	45%	44%	+1%	43%	46%	−3%	44%	44%	46%			
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	0.01			
Sig. between groups			Not Sig.			Not Sig.						Not Sig.
Fuel consumption												
2	28%	30%	−2%	30%	27%	+2%	28%	29%	28%			
4	34%	41%	−7%	38%	34%	+4%	43%	38%	26%			
6	42%	48%	−6%	43%	44%	−1%	45%	43%	45%			
8	34%	22%	+12%	29%	32%	−3%	26%	31%	34%			
10	25%	15%	+10%	19%	24%	−6%	15%	20%	31%			
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	0.05			
Sig. between groups			0.05			Not Sig.						Not Sig.
CO_2 Emissions												
50	28%	33%	−5%		32%	28%	+3%		32%	31%	26%	
90	31%	33%	−2%		30%	32%	−2%		35%	32%	27%	
110	34%	34%	0%		31%	36%	−5%		33%	32%	38%	
130	45%	41%	+3%		45%	42%	+3%		43%	42%	47%	
150	29%	23%	+6%		27%	27%	0%		21%	29%	29%	
Sig. within group	0.01	Not sig			0.01	0.01			0.05	Not Sig.	0.01	
Sig. between groups			Not Sig.				Not Sig.					Not Sig.

Table 6. Counting analysis for each consumer characteristics (cont).

Demographic variables									
	Route			Km per Year			Knowledge		
Attribute	City	Intercity	Dif.	≤30,000	>30,000	Dif.	Low	Medium/High	Dif.
Type of engine									
BEV	25%	16%	+9%	21%	16%	+6%	19%	23%	−4%
PHEV	41%	41%	0%	42%	34%	+8%	38%	45%	−6%
HEV	36%	43%	−7%	40%	38%	+2%	44%	35%	9%
Gasoline	21%	36%	−15%	25%	49%	−24%	29%	27%	2%
Diesel	49%	48%	+1%	48%	50%	−2%	52%	45%	6%
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	
Sig. between groups			0.01			0.05			Not Sig.
Price									
24,000	40%	47%	−7%	42%	53%	−11%	45%	41%	+3%
27,000	47%	53%	−6%	49%	52%	−2%	54%	45%	+10%
30,000	32%	23%	+10%	28%	25%	+3%	25%	31%	−6%
32,000	24%	25%	−1%	25%	17%	+8%	22%	26%	−4%
34,000	20%	17%	+3%	19%	14%	+5%	17%	21%	−4%
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	
Sig. between groups			Not Sig.			Not Sig.			Not Sig.
Range									
150	21%	12%	+9%	17%	13%	+4%	13%	20%	−7%
250	28%	18%	+10%	24%	20%	+4%	22%	25%	−3%
350	27%	21%	+6%	27%	10%	+17%	24%	24%	0%
900	30%	36%	−6%	31%	45%	−13%	33%	32%	+1%
1200	42%	46%	−4%	45%	42%	+2%	46%	43%	+3%
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	
Sig. between groups			0.05			Not Sig.			Not Sig.
Fuel consumption									
2	32%	24%	+8%	29%	25%	+4%	26%	32%	−6%
4	38%	34%	+5%	38%	23%	+15%	33%	39%	−6%
6	41%	47%	−5%	43%	48%	−5%	46%	41%	+5%
8	26%	35%	−9%	29%	43%	−15%	32%	28%	+4%
10	22%	22%	0%	21%	28%	−7%	25%	18%	+7%
Sig. within group	0.01	0.01		0.01	0.01		0.01	0.01	
Sig. between groups			Not Sig.			0.05			Not Sig.
CO_2 Emissions									
50	33%	27%	+6%	31%	25%	+5%	25%	35%	−10%
90	32%	31%	+1%	31%	36%	−5%	31%	31%	0%
110	30%	38%	−7%	34%	34%	0%	37%	30%	+7%
130	44%	43%	+2%	44%	40%	+5%	43%	44%	−1%
150	26%	29%	−3%	26%	32%	−6%	31%	23%	+7%
Sig. within group	0.01	0.01		0.01	Not Sig.		0.01	0.01	
Sig. between groups			Not Sig.			Not Sig.			0.05

Regarding the interaction with vehicle attributes we tested the hypotheses of demographic variables influencing consumers' sensitivity to vehicle attributes variations. A few statistically significant results were found that indicate an influence of demographic factors on vehicle attribute sensitivity, namely:

- Consumers with higher education are more price sensitive;
- City drivers are less sensitive to range;
- Older consumers and consumers that drive less are more sensitive to fuel consumption;
- Lower knowledge consumers are less sensitive to lower emission values.

7. Main Conclusions and Discussion

To the authors' best knowledge, this is the first in-depth review focused on the influence of consumer demographics on preferences for AFVs and their attributes. It summarizes the research paths that have been treaded during the last decades, providing insights on the main trends in AFVs market studies. This study also adds to the literature by analyzing the influence of demographic characteristics on preferences of Portuguese consumers.

Considering the target markets for consumer preferences research, the review showed an increasing number of studies in European and Asian countries. When specific vehicle technologies are focused, BEVs increasingly continue to attract interest from researchers worldwide.

Identifying the influence of consumer demographics in the consumer willingness to buy AFVs helps to understand the influence of such factors in the acceptability of those technologies [117] and it supports the market penetration strategies for these vehicles by policy-makers [17]. In this sense, the present review of the influence of consumers' characteristics on their preferences provided some directions that can be used in future policies implementation. Seven individual characteristics were selected for a thorough analysis: age, gender, income, level of education, family size, driving habits and number of vehicles owned per household. Their influence was analyzed according to the vehicle technologies. As the influence of consumers' age revealed contradictory results regarding all technologies, a complementary analysis considering the consumers geographical region was made in order to analyze if more consistent outcomes were found. This revealed that younger consumers have stronger preferences for AFVs in European and North American studies, whereas older consumers in Asia are more willing to buy these vehicles. Considering the consumers' income influence, no consistent results were found. Regarding the other demographic characteristics, it was verified that consumers with higher education levels, women and consumers with larger families have higher preferences for AFVs.

Knowing which consumers segments have higher propensities for AFVs may support strategic decisions of vehicle manufacturers concerning the introduction of these vehicles in the market, such as marketing campaigns focused on those segments. In addition, policy-makers can use that information to support policy design aiming at increasing the market penetration of AFVs. Regarding the vehicle-related demographics, it was observed that the influence of driving habits on AFVs preferences is linked to the technical limitations of these vehicles, mainly limited range and fuel availability. The analysis of the influence of the number of vehicles owned showed that it may depend on the vehicle type and suggests that crossing it with the wealth of the households could help to explain their influence on consumer preferences.

Regarding the study of preferences in Portugal, the results provided several insights about the influence of demographic variables on vehicle choice and on sensitivity to vehicle attributes. The results showed that demographic variables frequently influenced preferences for the type of vehicles chosen, mainly, age, type of route and annual distance driven by consumers. Acknowledging the lack of information from previous studies concerning significant relationships between demographic characteristics and preferences for vehicle attributes, this study presents new insights about vehicle attributes sensitivity, namely the influence of age and annual distance on fuel consumption, the

influence of route on range and the influence of knowledge on CO_2 emissions. Among the relationships found between demographics and vehicle attributes preferences, there were two which had an unexpected direction, namely the higher price sensitivity from high educated consumers and the higher sensitivity to fuel consumption from consumers that drive less. Concerning the first relationship, it can be considered counterintuitive because higher educated consumers tend to be wealthier and therefore less sensitive to price. We conjecture that this might not be the case among our convenience sample, which included many young Portuguese with college degrees, but who nowadays often earn less than older consumers without a degree. Another possible explanation is that better numeracy leads higher educated consumers to be more attentive to cost implications. Concerning the second relationship, one would expect that consumers driving less can afford a higher cost per km. A possible explanation for the relationship found is that consumers avoid driving, or drive less, when fuel price is higher due to their higher sensitivity to higher driving costs, but this relationship should be further examined in future studies. No relationship was found regarding the influence of gender on vehicle attributes preferences, contrary to previous studies that found significant relationships between gender and several attributes.

8. Research Gaps and Recommendations for Future Research

Throughout this review three main gaps have been identified which should be addressed in future studies. One gap concerns to the lack of studies focused on consumer preferences for PHEVs. Given that PHEVs are a combination of BEVs and conventional vehicles, they offer the comfort of a "safe ground" from their fuel-based component that reduces the known range anxiety from pure electric vehicles and, at the same time, they also imply a change of habits to consumers through the need of plugging in to charge the vehicle batteries. Consequently, by increasing consumers' familiarity with the electric-related habits, PHEVs may act as a transitional technology for BEVs, by attenuating the consumers resistance to BEVs, similarly to the transitional role of HEVs for PHEVs adoption found in the US [118]. In this context, identifying the characteristics of consumers that are more willing to buy these vehicles could support strategies to increase the market penetration of PHEVs, and later BEVs.

Another gap is related to the geographical scope of the analyzed studies. There are several countries whose governments have made efforts to effectively introduce electric vehicles, namely France, Sweden, Portugal, Italy, Greece [119]. However, research on consumer's preferences in these countries is still lacking in order to understand which consumers segments have higher propensities to adopt AFVs. The present study contributed with insights for the Portuguese market, but future studies should address the remaining unstudied markets to support the existent strategies to increase AFVs circulation or to help design more effective ones.

The third and final gap was the lack of studies that analyze the influence of consumer demographics on preferences for vehicle attributes. Only a few studies (15%) analyzed this interaction and very few found any significant relationship. Therefore, there are plenty relationships between individual characteristics and vehicle attributes to be addressed, e.g., age vs. range or route vs. fuel consumption. This information could be valuable for future AFVs promotion strategies.

Considering the summarized results of this study some recommendations for future consumer preference studies can also be made. One suggestion comes from the findings of the age influence analysis on consumer preferences for AFVs, where it was necessary to cross two consumer characteristics (age and geographic area) to identify trends on consumer preferences for AFVs. Therefore, for future studies, we suggest the analysis of interactions between individual characteristics in order to verify if relations can be identified. A specific suggestion comes from one of the highest concerns about BEVs, the limited range, which can be surpassed if consumers have a second vehicle for long-distance journeys. Therefore, as wealthy consumers probably have more than one vehicle, we suggest an analysis focused on the interaction between consumers' income and willingness to buy BEVs as primary and as second vehicles. Given the inconclusive results about the income

influence on preferences for AFVs more research is needed to clarify the willingness to buy AFVs by wealthy consumers.

The overall results of the demographics influence on preferences for AFVs of this review, by identifying a frequent positive or negative influence of each demographic factor on preferences, stress a recommendation for future studies to include a segmentation analysis which takes into account the consumer preferences heterogeneity. This review provides some insights about which segments should be considered as a starting point, such as highly educated women or larger families with several vehicles. The methodological approaches of the most recent studies in this review underline the importance of targeting specific groups of consumers by including latent class models that allow the identification of market segments with similar preferences [17,76,78].

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References

1. European Commission. *Statistical Pocketbook 2018*; European Commission: Brussels, Belgium, 2018.
2. IPCC. *Global Warming of 1.5 °C*; Report from Intergovernmental Panel on Climate Change; IPCC: Geneva, Switzerland, 2018.
3. Ahn, J.; Jeong, G.; Kim, Y. A forecast of household ownership and use of alternative fuel vehicles: A multiple discrete-continuous choice approach. *Energy Econ.* **2008**, *30*, 2091–2104. [CrossRef]
4. García, I.; Miguel, L.J. Is the electric vehicle an attractive option for customers? *Energies* **2012**, *5*, 71–91. [CrossRef]
5. Potoglou, D.; Kanaroglou, P.S. Household demand and willingness to pay for clean vehicles. *Transp. Res. D Transp. Environ.* **2007**, *12*, 264–274. [CrossRef]
6. Hidrue, M.K.; Parsons, G.R.; Kempton, W.; Gardner, M.P. Willingness to pay for electric vehicles and their attributes. *Resour. Energy Econ.* **2011**, *33*, 686–705. [CrossRef]
7. Wang, Y.; Liu, Z.; Shi, J.; Wu, G.; Wang, R. Joint optimal policy for subsidy on electric vehicles and infrastructure construction in highway network. *Energies* **2018**, *11*, 2479. [CrossRef]
8. ICTT. *European Vehicle Market Statistics: Pocketbook 2017/18*; ICTT: Berlin, Germany, 2017.
9. EPA. *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2014*; United States Environmental Protection Agency: Washington, DC, USA, 2014.
10. Electric Vehicle Sales Growing, but Supply, Lack of Knowledge Remain Barriers. Available online: https://www.ctvnews.ca/autos/electric-vehicle-sales-growing-but-supply-lack-of-knowledge-remain-barriers-1.4060309 (accessed on 28 December 2018).
11. Lack of Models, not Charging Points, Holding Back Electric Car Market. Available online: https://www.theguardian.com/environment/2018/feb/27/lack-of-models-not-charging-points-holding-back-electric-car-market (accessed on 28 December 2018).
12. Sovacool, B.; Hirsh, R. Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. *Energy Policy* **2008**, *37*, 1095–1103. [CrossRef]
13. Kemp, R.; Schot, J.; Hoogma, R. Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technol. Anal. Strateg.* **1998**, *10*, 175–195. [CrossRef]
14. Leiby, P.; Rubin, J. Understanding the transition to new fuels and vehicles: Lessons learned from analysis and experience of alternative fuel and hybrid vehicles. In *The Hydrogen Energy Transition: Moving Toward the Post Petroleum Age in Transportation*; Sperling, D., Cannon, J.S., Eds.; Elsevier Academic Press: Burlington, MA, USA, 2004.

15. Urban, G.L.; Weinberg, B.D.; Hauser, J.R. Premarket forecasting of really-new products. *J. Mark.* **1996**, *60*, 47–60. [CrossRef]
16. Ewing, G.; Sarigöllü, E. Car fuel-type choice under travel demand management and economic incentives. *Transp. Res. D Transp. Environ.* **1998**, *3*, 429–444. [CrossRef]
17. Axsen, J.; Bailey, J.; Andrea, M. Preference and lifestyle heterogeneity among potential plug-in electric vehicle buyers. *Energy Econ.* **2015**, *50*, 190–201. [CrossRef]
18. Hoen, A.; Koetse, M.J. A choice experiment on alternative fuel vehicle preferences of private car owners in the Netherlands. *Transp. Res. A Policy Pract.* **2014**, *61*, 199–215. [CrossRef]
19. Shin, J.; Bhat, C.R.; You, D.; Garikapati, V.M.; Pendyala, R.M. Consumer preferences and willingness to pay for advanced vehicle technology options and fuel types. *Transp. Res. C Emerg. Technol.* **2015**, *60*, 511–524. [CrossRef]
20. Achtnicht, M.; Bühler, G.; Hermeling, C. The impact of fuel availability on demand for alternative-fuel vehicles. *Transp. Res. D Transp. Environ.* **2012**, *17*, 262–269. [CrossRef]
21. Ziegler, A. Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transp. Res. A Policy Pract.* **2012**, *46*, 1372–1385. [CrossRef]
22. Ito, N.; Takeuchi, K.; Managi, S. Willingness-to-pay for infrastructure investments for alternative fuel vehicles. *Transp. Res. D Transp. Environ.* **2013**, *18*, 1–8. [CrossRef]
23. Hackbarth, A.; Madlener, R. Consumer preferences for alternative fuel vehicles: A discrete choice analysis. *Transp. Res. D Transp. Environ.* **2013**, *25*, 5–17. [CrossRef]
24. Tanaka, M.; Ida, T.; Murakami, K.; Friedman, L. Consumers' willingness to pay for alternative fuel vehicles: A comparative discrete choice analysis between the US and Japan. *Transp. Res. A Policy Pract.* **2014**, *70*, 194–209. [CrossRef]
25. Huang, Y.; Qian, L. Consumer preferences for electric vehicles in lower tier cities of China: Evidences from south Jiangsu region. *Transp. Res. D Transp. Environ.* **2018**, *63*, 482–497. [CrossRef]
26. Sheldon, T.L.; Deshazo, J.R.; Carson, R.T. Electric and plug-in hybrid vehicle demand: Lessons for an emerging market. *Econ. Inq.* **2017**, *55*, 695–713. [CrossRef]
27. Turcksin, L.; Mairesse, O.; Macharis, C. Private household demand for vehicles on alternative fuels and drive trains: A review. *Eur. Transp. Res. Rev.* **2013**, *5*, 149–164. [CrossRef]
28. Green, P.E.; Krieger, A.M.; Wind, Y. Thirty years of conjoint analysis: Reflections and prospects. *Interfaces* **2001**, *31*, 56–73. [CrossRef]
29. Da Silva, M.B.; Moura, F. Electric vehicle diffusion in the Portuguese automobile market. *Int. J. Sustain. Transp.* **2016**, *10*, 49–64. [CrossRef]
30. Potoglou, D.; Kanaroglou, P.S. Disaggregate demand analyses for conventional and alternative fueled automobiles: A review. *Int. J. Sustain. Transp.* **2008**, *2*, 234–259. [CrossRef]
31. Al-Alawi, B.M.; Bradley, T.H. Review of hybrid, plug-in hybrid, and electric vehicle market modeling studies. *Renew. Sustain. Energy Rev.* **2013**, *21*, 190–203. [CrossRef]
32. Rezvani, Z.; Jansson, J.; Bodin, J. Advances in consumer electric vehicle adoption research: A review and research agenda. *Transp. Res. D Transp. Environ.* **2015**, *34*, 122–136. [CrossRef]
33. Liao, F.; Molin, E.; Wee, B.V. Consumer preferences for electric vehicles: A literature review. *Transp. Rev.* **2017**, *37*, 252–275. [CrossRef]
34. Verlegh, P.W.J.; Steenkamp, J.-B.E.M. A review and meta-analysis of country-of-origin research. *J. Econ. Psychol.* **1999**, *20*, 521–546. [CrossRef]
35. Beggs, S.; Cardell, S.; Hausman, J. Assessing the potential demand for electric cars. *J. Econom.* **1981**, *16*, 1–19. [CrossRef]
36. Calfee, J. Estimating the demand for electric automobiles using fully disaggregated probabilistic choice analysis. *Transp. Res. B Methodol.* **1985**, *19*, 287–301. [CrossRef]
37. Bunch, D.S.; Golob, T.F.; Occhiuzzo, G.P. Demand for clean-fuel vehicles in California: A discrete-choice stated preference pilot project. *Transp. Res. A Policy Pract.* **1993**, *27A*, 237–253. [CrossRef]
38. Golob, T.; Kitamura, R.; Bradley, M.; Bunch, D. Predicting the market penetration of electric and clean-fuel vehicles. *Sci. Total Environ.* **1993**, *134*, 371–381. [CrossRef]
39. Brownstone, D.; Bunch, D.S.; Golob, T.F.; Ren, W. A transactions choice model for forecasting demand for alternative-fuel vehicles. *Res. Transp. Econ.* **1996**, *4*, 87–129. [CrossRef]

40. Kurani, K.S.; Turrentine, T.; Sperling, D. Testing electric vehicle demand in hybrid households using a reflexive survey. *Transp. Res. D Transp. Environ.* **1996**, *1*, 131–150. [CrossRef]
41. Chéron, E.; Zins, M. Electric vehicle purchasing intentions: The concern over battery charge duration. *Transp. Res. A Policy Pract.* **1997**, *31*, 235–243. [CrossRef]
42. Tompkins, M.; Bunch, D. Determinants of alternative fuel vehicle choice in the continental United States. *Transp. Res. Rec. J. Transp. Res. B* **1998**, *1641*, 130–138. [CrossRef]
43. Kavalec, C. Vehicle choice in an aging population: Some insights from a stated preference survey for California. *Energy J.* **1999**, *20*, 123–128. [CrossRef]
44. Brownstone, D.; Bunch, D.S.; Train, K. Joint mixed logit models of stated and revealed preferences for alternative-fuel vehicles. *Transp. Res. B Methodol.* **2000**, *34*, 315–338. [CrossRef]
45. Ewing, G.; Sarigöllü, E. Assessing consumer preferences for clean-fuel vehicles: A discrete choice experiment. *J. Public Policy Mark.* **2000**, *19*, 106–118. [CrossRef]
46. Dagsvik, J.K.; Wennemo, T.; Wetterwald, D.G.; Aaberge, R. Potential demand for alternative fuel vehicles. *Transp. Res. B Methodol.* **2002**, *36*, 361–384. [CrossRef]
47. Horne, M.; Jaccard, M.; Tiedemann, K. Improving behavioral realism in hybrid energy-economy models using discrete choice studies of personal transportation decisions. *Energy Econ.* **2005**, *27*, 59–77. [CrossRef]
48. Hess, S.; Train, K.E.; Polak, J.W. On the use of a Modified Latin Hypercube Sampling (MLHS) method in the estimation of a mixed logit model for vehicle choice. *Transp. Res. B Methodol.* **2006**, *40*, 147–163. [CrossRef]
49. Bolduc, D.; Boucher, N.; Alvarez-daziano, R.; Laval, U. Hybrid choice modeling of new technologies for car use in Canada. *Transp. Res. Rec. J. Transp. Res. B* **2008**, *2082*, 1–18.
50. Mau, P.; Eyzaguirre, J.; Jaccard, M.; Collinsdodd, C.; Tiedemann, K. The 'neighbor effect': Simulating dynamics in consumer preferences for new vehicle technologies. *Ecol. Econ.* **2008**, *68*, 504–516. [CrossRef]
51. Axsen, J.; Mountain, D.C.; Jaccard, M. Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. *Resour. Energy Econ.* **2009**, *31*, 221–238. [CrossRef]
52. Dagsvik, J.K.; Liu, G. A framework for analyzing rank ordered data with application to automobile demand. *Transp. Res. A Policy Pract.* **2009**, *43*, 1–12. [CrossRef]
53. Caulfield, B.; Farrell, S.; McMahon, B. Examining individuals preferences for hybrid electric and alternatively fuelled vehicles. *Transp. Policy* **2010**, *17*, 381–387. [CrossRef]
54. Kudoh, Y.; Motose, R. Changes of Japanese consumer preference for electric vehicles. *World Electr. Veh. J.* **2011**, *4*, 880–889. [CrossRef]
55. Eggers, F.; Eggers, F. Where have all the flowers gone? Forecasting green trends in the automobile industry with a choice-based conjoint adoption model. *Technol. Forecast. Soc.* **2011**, *78*, 51–62. [CrossRef]
56. Hensher, D.A.; Greene, W.H. Random regret minimization or random utility maximization: An exploratory analysis in the context of automobile fuel choice. *J. Adv. Transp.* **2011**, *47*, 667–678. [CrossRef]
57. Mabit, S.L.; Fosgerau, M. Demand for alternative-fuel vehicles when registration taxes are high. *Transp. Res. D Transp. Environ.* **2011**, *16*, 225–231. [CrossRef]
58. Qian, L.; Soopramanien, D. Heterogeneous consumer preferences for alternative fuel cars in China. *Transp. Res. D Transp. Environ.* **2011**, *16*, 607–613. [CrossRef]
59. Şentürk, I.; Erdem, C.; Şimşek, T.; Kılınç, N. Determinants of vehicle fuel-type preference in developing countries: A case of Turkey. *Int. J. Glob. Warm.* **2011**, *3*, 329–338. [CrossRef]
60. Zhang, T.; Gensler, S.; Garcia, R. A study of the Diffusion of Alternative Fuel Vehicles: An Agent-Based Modeling Approach. *J. Prod. Innov. Manag.* **2011**, *28*, 152–168. [CrossRef]
61. Zhang, Y.; Yu, Y.; Zou, B. Analyzing public awareness and acceptance of alternative fuel vehicles in China: The case of EV. *Energy Policy* **2011**, *39*, 7015–7024. [CrossRef]
62. Hess, S.; Fowler, M.; Adler, T. A joint model for vehicle type and fuel type. *Transportation* **2012**, *39*, 593–625. [CrossRef]
63. Lebeau, K.; Mierlo, J.V.; Lebeau, P.; Mairesse, O.; Macharis, C. The market potential for plug-in hybrid and battery electric vehicles in Flanders: A choice-based conjoint analysis. *Transp. Res. D Transp. Environ.* **2012**, *17*, 592–597. [CrossRef]
64. Alvarez-Daziano, R.; Bolduc, D. Incorporating pro-environmental preferences toward green automobile technologies through a Bayesian Hybrid Choice Model. *Transportmetrica A* **2013**, *9*, 74–106. [CrossRef]
65. Alvarez-Daziano, R.; Chiew, E. On the effect of the prior of Bayes estimators of the willingness to pay for electric-vehicle driving range. *Transp. Res. D Transp. Environ.* **2013**, *21*, 7–13. [CrossRef]

66. Axsen, J.; Orlebar, C.; Skippon, S. Social influence and consumer preference formation for pro-environmental technology: The case of a U.K. workplace electric-vehicle study. *Ecol. Econ.* **2013**, *95*, 96–107. [CrossRef]
67. Beck, M.J.; Rose, J.M.; Hensher, D.A. Environmental attitudes and emissions charging: An example of policy implications for vehicle choice. *Transp. Res. A Policy Pract.* **2013**, *50*, 171–182. [CrossRef]
68. Chorus, C.G.; Koetse, M.J.; Hoen, A. Consumer preferences for alternative fuel vehicles: Comparing a utility maximization and a regret minimization model. *Energy Policy* **2013**, *61*, 901–908. [CrossRef]
69. Jensen, A.F.; Cherchi, E.; Mabit, S.L. On the stability of preferences and attitudes before and after experiencing an electric vehicle. *Transp. Res. D Transp. Environ.* **2013**, *25*, 24–32. [CrossRef]
70. Glerum, A.; Stankovikj, L.; Thémans, M.; Bierlaire, M. Forecasting the demand for electric vehicles: Accounting for attitudes and perceptions. *Transp. Sci.* **2014**, *48*, 483–499. [CrossRef]
71. Parsons, G.R.; Hidrue, M.K.; Kempton, W.; Gardner, M.P. Willingness to pay for vehicle-to-grid (V2G) electric vehicles and their contract terms. *Energy Econ.* **2014**, *42*, 313–324. [CrossRef]
72. Hevelston, J.; Liu, Y.; Mcdonnell, E.; Fuchs, E.; Klampfl, E.; Michalek, J.J. Will subsidies drive electric vehicle adoption? Measuring consumer preferences in the U.S. and China. *Transp. Res. A Policy Pract.* **2015**, *73*, 96–112. [CrossRef]
73. Lieven, T. Policy measures to promote electric mobility—A global perspective. *Transp. Res. A Policy Pract.* **2015**, *82*, 78–93. [CrossRef]
74. Qian, L.; Soopramanien, D. Incorporating heterogeneity to forecast the demand of new products in emerging markets: Green cars in China. *Technol. Forecast. Soc.* **2015**, *91*, 33–46. [CrossRef]
75. Valeri, E.; Danielis, R. Simulating the market penetration of cars with alternative fuelpowertrain technologies in Italy. *Transp. Policy* **2015**, *37*, 44–56. [CrossRef]
76. Axsen, J.; Goldberg, S.; Bailey, J. How might potential future plug-in electric vehicle buyers differ from current 'Pioneer' owners? *Transp. Res. D Transp. Environ.* **2016**, *47*, 357–370. [CrossRef]
77. Bahamonde-birke, F.J.; Hanappi, T. The potential of electromobility in Austria: Evidence from hybrid choice models under the presence of unreported information. *Transp. Res. A Policy Pract.* **2016**, *83*, 30–41. [CrossRef]
78. Hackbarth, A.; Madlener, R. Willingness-to-pay for alternative fuel vehicle characteristics: A stated choice study for Germany. *Transp. Res. A Policy Pract.* **2016**, *85*, 89–111. [CrossRef]
79. Krause, R.M.; Lane, B.W.; Carley, S.; Graham, J.D. Assessing demand by urban consumers for plug-in electric vehicles under future cost and technological scenarios. *Int. J. Sustain. Transp.* **2016**, *10*, 742–751. [CrossRef]
80. Rudolph, C. How may incentives for electric cars affect purchase decisions? *Transp. Policy* **2016**, *52*, 113–120. [CrossRef]
81. Beck, M.J.; Rose, J.M.; Greaves, S.P. I can't believe your attitude: A joint estimation of best worst attitudes and electric vehicle choice. *Transportation* **2017**, *44*, 753–772. [CrossRef]
82. Cherchi, E. A stated choice experiment to measure the effect of informational and normative conformity in the preference for electric vehicles. *Transp. Res. A Policy Pract.* **2017**, *100*, 88–104. [CrossRef]
83. Cirillo, C.; Liu, Y.; Maness, M. A time-dependent stated preference approach to measuring vehicle type preferences and market elasticity of conventional and green vehicles. *Transp. Res. A Policy Pract.* **2017**, *100*, 294–310. [CrossRef]
84. Dimatulac, T.; Maoh, H. The spatial distribution of hybrid electric vehicles in a sprawled mid-size Canadian city: Evidence from Windsor, Canada. *J. Transp. Geogr.* **2017**, *60*, 59–67. [CrossRef]
85. Higgins, C.D.; Mohamed, M.; Ferguson, M.R. Size matters: How vehicle body type affects consumer preferences for electric vehicles. *Transp. Res. A Policy Pract.* **2017**, *100*, 182–201. [CrossRef]
86. Jensen, A.F.; Cherchi, E.; Mabit, S.L.; Ortúzar, J.D.D. Predicting the potential market for electric vehicles. *Transp. Sci.* **2017**, *51*, 427–440. [CrossRef]
87. Liu, Y.; Cirillo, C. A generalized dynamic discrete choice model for green vehicle adoption. *Transp. Res. Procedia* **2017**, *23*, 868–886. [CrossRef]
88. Ma, S.; Gao, P.; Tan, H. The impact of subsidies and charging facilities on demand for electric vehicles in China. *Environ. Urban* **2017**, *8*, 230–242. [CrossRef]
89. Smith, B.; Olaru, D.; Jabeen, F.; Greaves, S. Electric vehicles adoption: Environmental enthusiast bias in discrete choice models. *Transp. Res. D Transp. Environ.* **2017**, *51*, 290–303. [CrossRef]
90. Byun, H.; Shin, J.; Lee, C.-Y. Using a discrete choice experiment to predict the penetration possibility of environmentally friendly vehicles. *Energy* **2018**, *144*, 312–321. [CrossRef]

91. Choi, H.; Shin, J.; Woo, J. Effect of electricity generation mix on battery electric vehicle adoption and its environmental impact. *Energy Policy* **2018**, *121*, 13–24. [CrossRef]
92. Costa, E.; Montemurro, D.; Giuliani, D. Consumers' willingness to pay for green cars: A discrete choice analysis in Italy. In *Environment, Development and Sustainability*; Springer: Dordrecht, The Netherlands, 2018; pp. 1–18.
93. Ferguson, M.; Mohamed, M.; Higgins, C.D.; Abotalebi, E.; Kanaroglou, P. How open are Canadian households to electric vehicles? A national latent class choice analysis with willingness-to-pay and metropolitan characterization. *Transp. Res. D Transp. Environ.* **2018**, *58*, 208–224. [CrossRef]
94. Hahn, J.-S.; Lee, J.-H.; Choi, K. Heterogeneous preferences of green vehicles by vehicle size: Analysis of Seoul case. *Int. J. Sustain. Transp.* **2018**, 1–11. [CrossRef]
95. Liao, F.; Molin, E.; Timmermans, H.; Wee, B.V. The impact of business models on electric vehicle adoption: A latent transition analysis approach. *Transp. Res. A Policy Pract.* **2018**, *116*, 531–546. [CrossRef]
96. Liu, Y.; Cirillo, C. Modeling green vehicle adoption: An integrated approach for policy evaluation. *Int. J. Sustain. Transp.* **2018**, 1–11. [CrossRef]
97. Soto, J.J.; Cantillo, V.; Arellana, J. Incentivizing alternative fuel vehicles: The influence of transport policies, attitudes and perceptions. *Transportation* **2018**, 1–33. [CrossRef]
98. Wolbertus, R.; Kroesen, M.; Hoed, R.V.D.; Chorus, C.G. Policy effects on charging behaviour of electric vehicle owners and on purchase intentions of prospective owners: Natural and stated choice experiments. *Transp. Res. D Transp. Environ.* **2018**, *62*, 283–297. [CrossRef]
99. Laroche, M.; Bergeron, J.; Barbaro-Forleo, G. Targeting consumers who are willing to pay more for environmentally friendly products. *J. Consum. Mark.* **2001**, *18*, 503–520. [CrossRef]
100. Straughan, R.D.; Roberts, J.A. Environmental segmentation alternatives: A look at green consumer behavior in the new millennium. *J. Consum. Mark.* **2011**, *16*, 558–575. [CrossRef]
101. Kaushik, A.K.; Rahman, Z. Perspectives and dimensions of consumer innovativeness: A literature review and future agenda. *J. Int. Consum. Mark.* **2014**, *26*, 239–263. [CrossRef]
102. Johnson, R.; Orme, B. *Sample Size Issues for Conjoint Analysis. Getting Started with Conjoint Analysis: Strategies for Product Design and Pricing Research*; Research Publishers LLC: Madison, WI, USA, 2010; pp. 57–66.
103. Laukkanen, T.; Laukkanen, P. Innovation resistance among mature consumers. *J. Consum. Mark.* **2007**, *24*, 419–427. [CrossRef]
104. Lambert-Pandraud, R.; Gilles, L. Why do older consumers buy older brands? The role of attachment and declining innovativeness. *J. Mark.* **2010**, *74*, 104–121. [CrossRef]
105. Leventhal, R.C. Aging consumers and their effects on the marketplace. *J. Consum. Mark.* **1997**, *14*, 276–281. [CrossRef]
106. Tellis, G.J.; Yin, E.; Bell, S. Global consumer innovativeness: Cross-country differences and demographic commonalities. *J. Int. Mark.* **2009**, *17*, 1–22. [CrossRef]
107. Lim, H.; Park, J.-S. The effects of national culture and cosmopolitanism on consumers' adoption of innovation: A cross-cultural comparison. *J. Int. Consum. Mark.* **2013**, *25*, 16–28. [CrossRef]
108. Kim, W.; Benedetto, C.A.D.; Lancioni, R.A. The effects of country and gender differences on consumer innovativeness and decision processes in a highly globalized high-tech product market. *Asia Pac. J. Mark. Logist.* **2011**, *23*, 714–744. [CrossRef]
109. Pinto, D.C.; Herter, M.M.; Rossi, P.; Borges, A. Going green for self or for others? Gender and identity salience effects on sustainable consumption. *Int. J. Consum. Stud.* **2014**, *38*, 540–549. [CrossRef]
110. Im, S.; Bayus, B.L.; Mason, C.H. An empirical study of innate consumer innovativeness, personal characteristics, and new-product adoption behavior. *J. Acad. Mark. Sci.* **2003**, *31*, 61–73. [CrossRef]
111. Lennon, S.J.; Johnson, K.K.P.; Jolly, L.D.; Jasper, C.R. A Longitudinal Look at Rural Consumer Adoption of Online Shopping. *Psychol. Mark.* **2007**, *24*, 375–401. [CrossRef]
112. Steenkamp, J.; Gielens, K. Consumer and market drivers of the trial probability of new consumer packaged goods. *J. Consum. Res.* **2003**, *30*, 368–384. [CrossRef]
113. Meyer, A. Does education increase pro-environmental behavior? Evidence from Europe. *Ecol. Econ.* **2015**, *116*, 108–121. [CrossRef]
114. IEA. Hybrid and electric vehicles: The electric drive delivers. In *Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes*; International Energy Agency: Paris, France, 2015.

115. Oliveira, G.D.; Dias, L.C. Which criteria matter when selecting a conventional or electric vehicle? In Proceedings of the Energy for Sustainability 2015—Sustainable Cities: Designing for People and the Planet, Coimbra, Portugal, 14–15 May 2015; pp. 1–10.
116. INE. *Censos 2011: Definitive Results—Portugal*; National Statistics Institute Report; INE: Lisbon, Portugal, 2012.
117. Huijts, N.M.A.; Molin, E.J.E.; Steg, L. Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renew. Sustain. Energy Rev.* **2012**, *16*, 525–531. [CrossRef]
118. Keith, D.R. Essays on the Dynamics of Alternative Fuel Vehicle Adoption: Insights from the Market for Hybrid- Electric Vehicles in the United States. Ph.D. Thesis, Engineering Systems Division, Massachusetts Institute of Technology, Cambridge, MA, USA, 2012.
119. ACEA. *Overview of Purchase and Tax Incentives for Electric Vehicles in the EU in 2015*; European Automobile Manufacturers Association: Brussels, Belgium, 2015.