SN Bus Econ (2023) 3:148
https://doi.org/10.1007/s43546-023-00524-2

ORIGINAL ARTICLE

The race of ecological vehicles: consumer behavior and generation impact in the Portuguese market

José Campino[1] · **Francisca Pereira Mendes**[2] · **Álvaro Rosa**[2]

Received: 23 November 2022 / Accepted: 3 July 2023

Abstract

The impacts of climate change are becoming increasingly severe and noticeable. Consumers are becoming more cognizant of the environmental challenges that affect the planet. A major contributor to carbon emissions and the resulting warming climate and pollution is transportation. As a result, the selection of environmentally friendly options in this industry is becoming a pressing matter. This study aims to examine the reasons that motivate consumers to choose eco-friendly vehicles. The study specifically aims to understand what factors drive consumers to purchase such vehicles. A questionnaire was administered to the Portuguese population to determine which factors influence the decision to purchase eco-friendly vehicles, and what type of vehicles are preferred. The study includes all types of eco-friendly vehicles, including early-stage solutions such as fuel cell vehicles. Furthermore, the study examines whether there is any difference in purchasing habits between generations. The study is based on several theories, including the Technology Acceptance Model (TAM), Diffusion of Innovation (DOI), Norm Activation Model (NAM), and Theory of Planned Behavior (TPB). Our research concludes that attitude (influenced by the advantages, compatibility, and non-complexity) and personal norms (influenced by the efficiency) are the two factors that affect positively and significantly the intention of purchase. The preferred eco-friendly vehicle among participants was found to be the hybrid electric vehicle, and the hydrogen fuel cell electric vehicle was also considered. The study did not find a significant impact of generation on purchasing decisions, but different generations were found to value different factors when making a vehicle purchase.

Keywords Consumer behavior · Ecological vehicles · Electric vehicles · Green hydrogen · Fuel cells · Generations

Extended author information available on the last page of the article

Published online: 21 July 2023

Introduction

Although the rapid progress of the global economy and technology caused civilizational advances and improved living conditions, it has also caused damage to the global environment (Tu and Yang 2019). Large-scale production can trigger climate change and global warming as the harmful emissions are mainly caused through the burning of fossil fuels (Xu et al. 2020) to which the transport system gives a large contribution (Asadi et al. 2021).

According to the International Energy Agency (IEA), the number of vehicles in use worldwide is about one million (Asadi et al. 2021), implying a daily consumption of approximately sixty million barrels, of which thirty-six million are associated with private vehicles leading to the emission of 14 million tons of carbon dioxide (Sang and Bekhet 2015). As 60% of carbon pollution in the transport industry is caused by passenger vehicles, green vehicles are a path to reduce these emissions (Featherman et al. 2021). Eco-vehicles are ecological vehicles made to help reduce the consumption of non-renewable resources, as well as the amount of CO2 produced. Therefore, they work more efficiently (i.e.: using less fuel), produce less CO2, and do not depend only on fossil fuel (TOYOTA 2021). Therefore, a vehicle is considered "green" if it pollutes less and is more fuel efficient when compared to other vehicles (USEPA 2022). Ecological vehicles can lead to a 30–50% reduction in carbon dioxide emissions and a 40–60% increase in fuel efficiency (Liu et al. 2019). There is also the argument considering that the increase in battery electric vehicles (BEVs) is more favorable to achieve environmental goals than the reduction of individual vehicles (Sonja and Fjendbo, 2018).

The main advantages of adopting an ecological vehicle are that it does not emit greenhouse gases, it is more cost-effective in terms of fuel costs, has lower maintenance costs and the fact that it can be considered more comfortable as it produces little vibration and almost no noise (Lashari et al. 2021). However, in case of purely electric vehicles (EVs), it must be considered that electricity must be produced from renewable sources to be a green alternative (Degrimenci and Breitner 2017). On the other hand, some barriers are, the high cost of purchase mainly due to the lack of economies of scale, underdeveloped charging infrastructures, the driving range is shorter, and the cost of a new battery is expensive (Lashari et al. 2021). It should also be noted that the type of battery used in EVs requires the use of materials such as lithium, nickel, and cobalt and, therefore, has a climate and environmental impact in addition to the electrical waste they can cause (Lim 2021).

According to the European Automobile Manufacturers' Association (ACEA), in the second quarter of 2021, the European market share of electric vehicles increased from 3.5% in 2020 to 7.5% in 2021 (Correia 2021). This way, it is relevant to understand what are the reasons that effectively lead consumers to opt for those types of vehicles. And, in the case of consumers who do not yet have them, understand if they have any interest in acquiring them in the future. Additionally, and according to Amnesty International, climate change is a fundamental issue for generation Z (Paiva 2019). Furthermore, gen Z shoppers demand sustainable retail as most consumers of this generation prefer sustainable brands (Petro 2021). By 2021, more

than a quarter of Gen Z and millennials said their purchasing decisions were influenced by the impact of certain businesses on the environment (Jahns 2021).

Therefore, it is of crucial importance to understand the factors that influence the purchase of an ecological vehicle and in particular the perception of the different generations towards the adoption of such solutions. Firstly, we will develop a model which summarizes the most important factors leading to the purchase of an ecological vehicle. Secondly, we will further develop our study to include a generational analysis in order to understand which factors are considered relevant, by the different age intervals, in the adoption of ecological vehicles. As we will explore in later chapters, the literature studied different aspects of the consumer behavior and several topics on the adoption of what are considered green solutions. However, to the best of our knowledge, there are no studies developing a theoretical model, testing it with real data and applying a generational analysis to this topic. Hence, we propose to help fulfill this literature gap with our research contributions.

Market snapshot

Types, functions and producers of eco-vehicles

The first green vehicles to be produced were hybrid electric vehicles (HEV). Hybrid vehicles run on full-size batteries and motor (Song et al. 2021). This way, an HEV consists of a vehicle with an internal combustion engine with battery and an electric motor that allows a reduction in emissions as well as greater fuel efficiency, that is, it minimizes dependence on fossil fuels (Baskar et al. 2020).

Like HEV, plug-in hybrid electric vehicles (PHEV) have an electric motor and a conventional one, but in this case, the electric motor can work without resorting to the conventional motor as it can be charged externally (Ekonomista 2020). Thus, PHEVs run primarily on batteries, but have a small reserve engine to extend the range (Song et al. 2021). Moreover, it saves as much energy as electric vehicles and is equally efficient when compared to conventional vehicles (Singh et al. 2021). Thus, the electric motor works alone to move the vehicle, but when the battery is no longer able to assist the engine, the internal combustion engine takes over and the vehicle runs on fuel (Singh et al. 2021).

Micro-hybrid vehicles run on a combustion engine that is assisted by a generator/electric motor and do not need an external charger as it is the case with plug-in hybrids (Ekonomista 2020). The main difference compared to conventional vehicles is the possibility of the built-in generator being able to function as an engine and, thus, energy savings are achieved when the vehicle is stationary (Melo 2016).

Battery electric vehicles (BEV) rely solely on a battery-powered electric motor. BEVs only work with batteries charged at electrical stations (Song et al. 2021). Since they do not have an internal combustion engine, BEVs do not create tailpipe emissions and noise pollution is diminished. In addition, there is a higher power-to-weight ratio, which translates into increased acceleration performance compared to conventional vehicles (Pilkington 2019).

Fuel cell electric vehicles (FCEV) are best known for their hydrogen option, namely, hydrogen fuel cell electric vehicles (HFCEV). They store energy in the form of hydrogen and generate electricity using oxygen cells (Moon et al. 2021). This type of vehicles stores the hydrogen in a highly secure compartment, then occurs the process of joining the hydrogen and the oxygen generating a reaction and producing electrical energy which causes movement (Ekonomista 2020). Therefore, there is a crucial difference between these vehicles and the other options: the hydrogen fuel cell vehicle produces electricity on their own, meaning that they do not need to save energy in a battery which reduces substantially the battery size (BMW 2020).

Individual versus public transportation in Portugal

In order to compare the evolution of the usage of private and public transportation, we have analyzed the number of private vehicles in circulation and the trips performed metro which serves as a proxy for other public transportation as is the most used for pendular trips, in Fig. 1. Although the metro option has become more popular, there is a clear difference between the constant increase in vehicles in circulation and the use of public transportation. This might mean the existence of an improving but still incipient public transportation system (Cruz et al. 2021) that does not meet the consumers' needs who prefer using private transportation. This fact urges the need to greener solutions in this area.

Evolution of electric vehicles consumption

To understand the evolution of electric vehicles consumption, the number of electric vehicles in use worldwide between 2016 and 2019 is graphically represented,

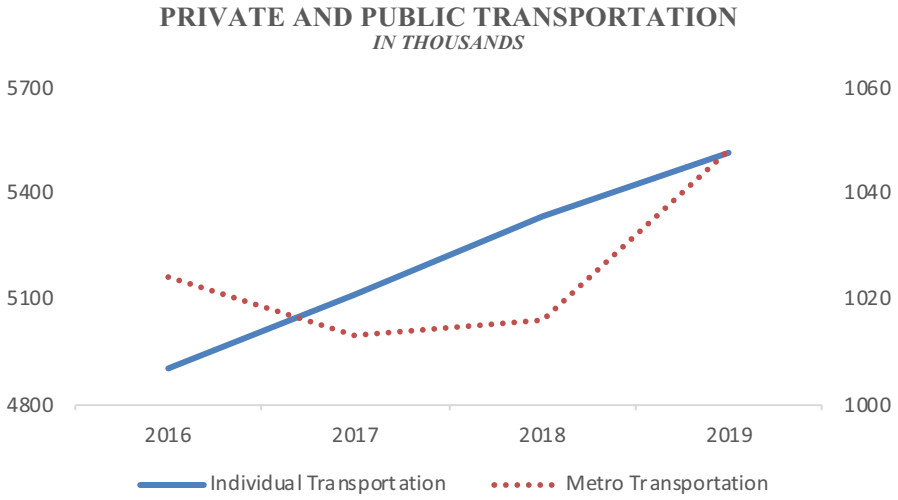

Fig. 1 Evolution of private (left axis) and public (right axis) transportation. Source: PORDATA

in Fig. 2. Since 2016, there has been a greater use of battery electric vehicles instead of plug-in electric vehicles. Even so, between these years, there has been a significant increase in the use of electric vehicles. In 2019, the number of electric vehicles in use worldwide was approximately 7.14 million, when compared to 2016, when there were only 2.01 million.

In 2020, Europe was the one with the highest registration of electric vehicles—1.4 million units, followed by China with 1.2 million units and, third, the United States with 295,000 units (IEA 2021). In 2020 the country that had the highest number of new registrations of electric vehicles was Germany, followed by Norway and then the United States. Portugal is in 11th position on this list, having registered 6,880 new battery electric vehicles and 5,773 new plug-in electric vehicles as per Fig. 3 (EEA 2022).

As shown in Fig. 3, the use of electric cars is increasing more and more, and perhaps one of the influential factors is the tax incentives and purchase incentives that each country has in relation to this type of vehicles. Consequently, 20 EU Member States offer incentives such as bonus or prize payments to electric vehicle consumers (EAMA 2020). However, 6 countries (i.e.: Belgium, Bulgaria, Cyprus, Denmark, Latvia, and Malta) do not offer purchase incentives, but grant reductions or tax exemptions for this type of vehicles. Lithuania is the only country that does not offer tax benefits nor incentives (EAMA 2020).

In Portugal, there are purchase incentives, for example, when buying a 100% electric vehicle in 2021, the consumer would receive €3,000 (DECO 2021). At the level of tax benefits, regarding the Vehicle Tax (ISV), fully electric cars are exempt and there is a 60% reduction for hybrids and 25% for plug-in hybrids (CGD 2021). Fully electric vehicles or vehicles powered by non-combustible renewable energies are also exempt from the Circulation Tax (IUC) (CGD 2021). In this way, it is not certain if this type of incentives promotes the purchase of

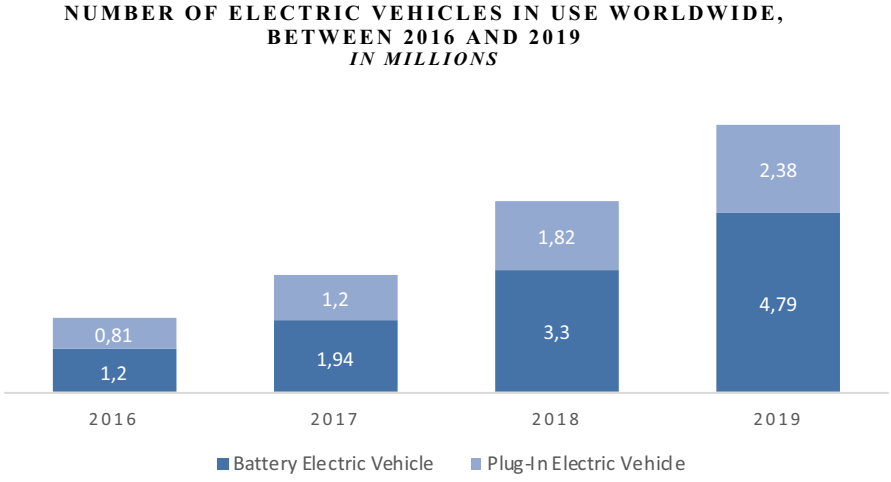

Fig. 2 Number of electric vehicles in use worldwide (in millions). Source: Statista

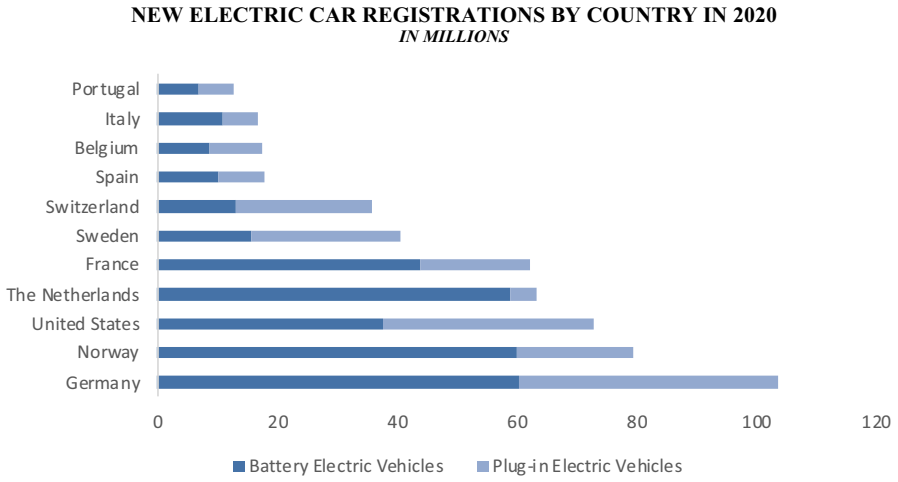

Fig. 3 New electric vehicles by country in 2020 (in millions). Source: EEA

electric cars, but it is certain that the countries that have them are those with more users.

Literature review

Theories and models of consumer behavior

Consumer behavior is the "consumer decisions regarding the acquisition, consumption, disposition of goods, services, time and ideas by human decision-making units over time" (Hoyer et al. 2012). The consumer behavior is often influenced by how others will react to their beliefs (Featherman et al. 2021). According to Goldsmith et al., (2000) people are concerned with what others think about them, and the behavior generally depends on social reputation. Therefore, consumers often make their choices and decisions based on their references (e.g.: friends, family, colleagues) and what they would do in that situation.

The Theory of Planned Behavior (TPB) was proposed by Ajzen (1991) and is depicted in Fig. 4. It is a social cognitive model that assumes that behavior is a linear function of behavioral intentions and perceived behavior control (PBC), the perception of individual control over the execution of the behavior (Sniehotta 2009).

The Norm Activation Model (NAM), depicted in Fig. 5, adds the contribution of pro-social incentives concept, which states that consumers make their decisions based on environmental attitudes (Asadi et al. 2021). Moreover, environmentally friendly behavior can be seen through three components: attribution of responsibility (AR), personal norms (PN) and awareness of consequences (AC) (Asadi et al. 2021). The AR reflects consumers' awareness of the negative results of not behaving in a pro-social way and the awareness of the problem, the NPs

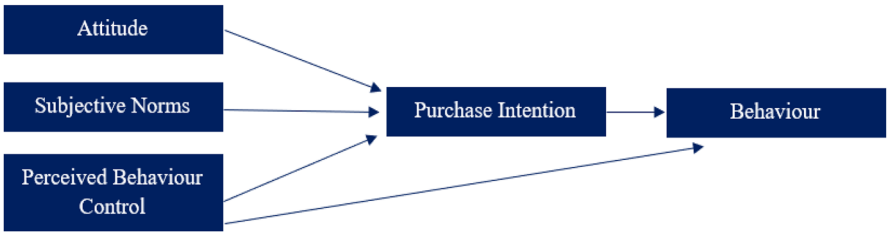

Fig. 4 Theory of planned behavior model

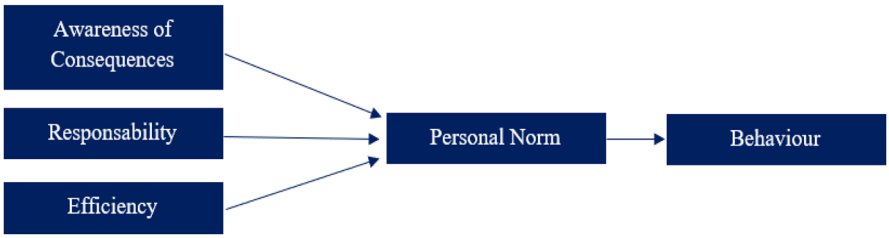

Fig. 5 Norm activation model

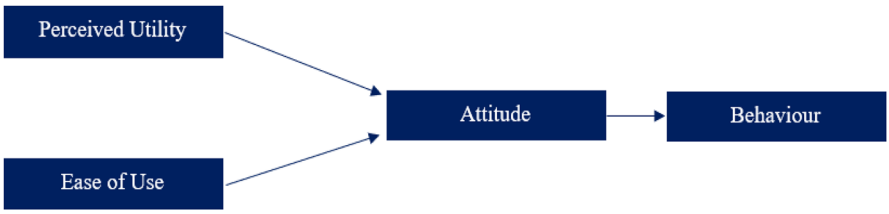

Fig. 6 Technology acceptance model

show a sense of commitment towards the unfavorable results of not following pro-social behaviors (De Groot and Steg 2007).

The Technology Acceptance Model (TAM), depicted in Fig. 6, is also relevant in the context of this study. The model was intends to highlight the factors that affect users' acceptance of technology and assumes the mediating role of two variables: perceived ease of use and perceived usefulness (Maranguié and Granié 2014).

The Diffusion of Innovation (DOI), depicted in Fig. 7, theory can be used to understand the motivations related to the adoption of green products (Dilotsotlhe and Duh 2021). This theory presents five perceived characteristics about innovation, (1) relative advantage—innovation is perceived as superior, (2) compatibility—the innovation is perceived as consistent, (3) complexity—innovation is perceived as relatively difficult to perceive and use, (4) experience—innovation can be experimented with and (5) observation—adoption effects are visible (Dilotsotlhe and Duh 2021).

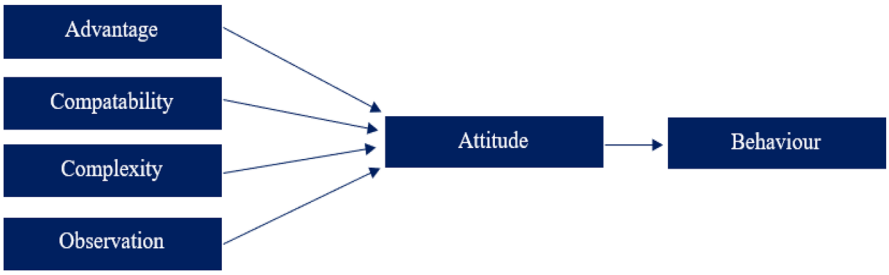

Fig. 7 Diffusion of innovation theory

Previous studies on electric vehicles

Several recent studies (Rahahleh et al. 2020; Dilotsotlhe and Duh 2021; Moon et al. 2021; Song et al. 2021; Asadi et al. 2021) have focused on the factors that influence the purchase of electric vehicles. Given that there are several factors that have already been studied to understand what drives consumers to choose an ecological vehicle, we have divided the factors into three categories: demographic, situational and psychological.

Demographic factors

Within the demographic group of factors, we have identified individual factors (i.e.: gender, age, education level, income, occupation) and family factors (i.e.: number of vehicles and accessibility of charging at home) (Li et al. 2017).

Lashari et al., (2021) indicate that men are more likely to buy EVs and younger men (i.e.: 20 to 30 years old) showed a negative association on the purchase intention. In contrast, Li et al., (2017) reported that young, well-educated, and male consumers are the ones with strong intentions to adopt EVs. And Simsekoglu and Nayum (2018) mention that being middle-aged (i.e.: 30–50), having a high education and having high incomes are characteristics that are positively associated with the adoption and use of EVs.

As for family factors, consumers who live in a rural or sub-rural area and who have several family members are considered the most likely to adopt BEVs (Li et al. 2017). They also add that having charging sources for BEVs at home or around drives the intention to adopt these vehicles (Li et al. 2017).

Situational factors

Within the situational factors category, we consider the technological attributes, the cost of the vehicle, environmental attributes, and government policies (Li et al. 2017). Regarding technological attributes, the main barriers for consumers are the driving range of BEVs, the long battery charging time and insufficient charging structures (Li et al. 2017) while Rodrigues et al., (2021) point out that consumers report that the main problem with EVs is the distance to charging stations.

According to Rezvani et al., (2015), the reasons that lead consumers to purchase EVs are technical factors, such as the performance of the vehicle, charging time, or safety. Khazaei (2019), on the other hand, shows that performance expectation is the factor that has a positive impact.

As for cost, while low operating costs are a positive factor, the high purchase cost is a barrier to the adoption of BEVs (Li et al. 2017). Lashari et al., (2021), say that the purchase price of the vehicle is the most important variable and Rezvani et al., (2015), support that the vehicle purchase cost is a reason to buy or not the vehicle.

Concerning environmental attributes, consumers are worried about the pollution generated through the process of producing batteries and electricity (Li et al. 2017). The studies by Wu et al., (2019), Rezvani et al., (2015), Zhang et al., (2018) and Rodrigues et al., (2021) shows that environmental concern has a significant association with intentions to purchase autonomous EVs. To overcome some barriers regarding green vehicles, governments have launched some incentives. Li et al., (2017) conclude that financial subsidies, tax reductions, free parking and driving privileges positively influence the adoption of BEVs which is accordance with Huang and Ge (2019). Additionally, Zhang et al., (2018) mention that one of the factors that consumers consider when buying an EV is incentive policies. However, economic incentives alone are not enough to make consumers adopt EVs (Bridi and Alhosani 2021).

Psychological factors

Lastly, the phycological factors are comprised of experience, attitudes, emoticons, perceived behavioral control, social influence, and symbols (Li et al. 2017). According to Li et al., (2017) when consumers drive BEVs, they perceive them more positively in relation to driving performance and do not consider battery charging a problem. The study by Skippon et al., (2016) showed that BEV performance ratings increase after trying them out, while purchase considerations decrease suggesting that "short-range disutility outweighs the perceived benefit of better performance and driving experience".

Huang and Ge (2019), mention that consumers who have a positive attitude towards the use and purchase of EVs are more likely to buy EVs. Thus, we can infer that attitude is a strong indicator of consumer purchase intention. Moreover, personal factors (attitude and perceived behavior control) are the main factors that influence consumer purchase intention (Huang and Ge 2019; Moons and Pelsmacker 2012). Moons and Pelsmacker (2015) point out that emotions in relation to electric vehicles are one of the most important factors that creates intention to buy EVs. And yet, Tu and Yang (2019) say that when consumers believe that EVs are more beneficial on a personal, environmental, and national level, or when they believe that it is easier and more convenient to use EVs, they have a positive attitude towards them. Another factor that has a strong impact on the attitude and purchase intention of EVs is their environmental performance (Degrimenci and Breitner 2017).

Several studies (Dilotsotlhe and Duh 2021; Asadi et al. 2021; Moons and Pelsmacker 2015), concluded that subjective norms, perceived behavior control and economic

attributes are positively related to the intention to purchase an EV. Also, studies that took TAM into account (Asadi et al. 2021), concluded that perceived relative advantage and perceived ease of use have a significant positive effect on purchase intention, while perceived risk has a negative effect (Xu et al. 2020). Additionally, Wu et al., (2019) showed that utility and ease of use have a significant association regarding purchase intentions of autonomous EVs. The study of Vafaei-Zadeh et al., (2022), concludes that perceived use and perceived ease of use have a positive effect on attitude while attitude, subjective norms, perceived behavior control, the price value and the environmental personal image have a negative impact on the intention to adopt these vehicles. Peters and Dutschke (2014) identify the "perceived compatibility of BEV with personal needs" as one of the most influential factors in the purchase intention of BEV.

Asadi et al. (2021), found that there are significant effects of personal norms on EV purchase intention. They also concluded that awareness of consequences and attribution of responsibilities are strongly and positively associated with personal norms (Asadi et al. 2021). And yet, consumers' awareness of the undesirable results of conventional vehicles, together with the individual's own commitment to these negative results, leads to the adoption of EVs due to the moral commitment to conserve the environment and save existing resources (Asadi et al. 2021).

Other factors to consider are, social influence and symbolic attributes related to EVs. According to Featherman et al., (2021) social influence positively influences consumers' purchase decisions in relation to EVs. Simsekoglu and Nayum (2018) say that symbolic attributes are related to the social part and personal identity and are important factors in the adoption of EVs. Consumers prefer products in which the symbolic meanings are congruent with their personal identity (Bridi and Alhosani 2021).

In addition to the mentioned variables, the credibility of the vehicle supplier was studied. According to Featherman et al., (2021), the supplier's claims about the performance and use of the product are considered the supplier is seen as reputable, reliable and an expert in this field. Featherman et al. (2021), mention that the experience and reliability of the seller exert a positive and direct influence on the decision to purchase EV and add that the seller's expertise can reduce consumer concerns.

Comparative studies regarding the intention of purchase of EVs

When comparing EV purchase intentions in China and the US, Song et al., (2021) found that Chinese respondents gave more importance than US respondents to the reputation and interest of third parties, while the US placed greater importance on economy, innovation and driving pleasure.

Sonja and Fjendbo (2018) suggest that those who own a conventional vehicle have symbolic attitudes with greater influence while BEV users said that functional barriers would be an important factor in the intention to purchase a BEV. Another important aspect was the price, which is a significant factor for users of conventional vehicles and for BEV users the same is not verified (Sonja and Fjendbo 2018).

Regarding FCEVs, technically, these can outperform BEVs in terms of a longer driving range and longer refueling time (Moon et al. 2021). Moon et al., (2021)

show convincing proof that consumers who tend to consider vehicles to be high-end and who tolerate low availability of charging infrastructures are the consumers most likely to adopt FCEV. However, according to Shin et al., (2019), EVs are preferable to HFCVs due to differences in infrastructure and prices.

Conceptual model

We have built a Structural Equations Model (SEM) as the basis of this research in order to explore the factors that lead consumers to opt for an ecological vehicle. This model is summarized in Fig. 8 and is based on the following theories: TAM, DOI, NAM, and TPB. We have defined the dependent variable as the purchase intention, which will potentially lead to behavior, namely, purchase of ecological vehicles. Mediation variables, which introduce a possible explanation between two variables (Saunders et al. 2019), are defined in our model as attitude and personal norm. As for the independent variables, we have defined the perceived utility, ease of use, relative advantage, compatibility, and complexity that are related to attitude. Furthermore, awareness of consequences, attribution of responsibility and perceived effectiveness of the consumer, impact the personal norm. Lastly, attitude, knowledge, subjective norm, perceived behavior control and personal norm influence purchase intention and, consequently, it influences behavior.

As a complement to the main SEM, which is the basis of our research, we have also performed several simple linear regressions using the OLS method and techniques to overcome any data drawbacks. The regressions had as dependent variable the purchase intention and as independent variables, the ones identified in SEM which were combined by groups for this purpose. The main objective of this analysis is to identify the impact of generations on the purchase intention of ecological

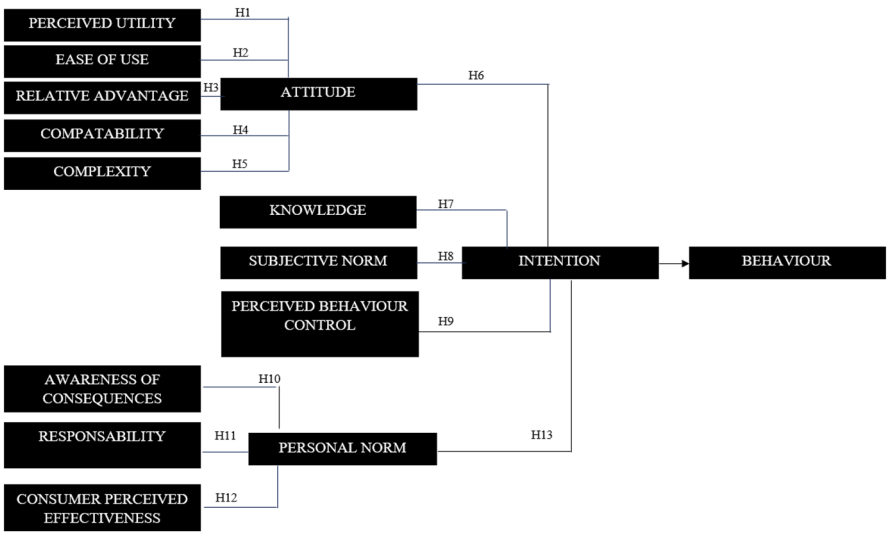

Fig. 8 Conceptual mode

vehicles. Therefore, we have used a base model controlling by age and subsequent models restricting the sample to individuals belonging to each generation. The last analysis allows us to understand which variables are important to each generation and if they change according to the year the individual was born.

Hypothesis

TAM suggests that what influences attitude is the perceived usefulness and the easiness of use (Maranguié and Granié, 2014). In this study, perceived usefulness means that when using an ecological vehicle, the consumer perceives it as being better for the environment (Maranguié and Granié, 2014). The ease of use refers to the easiness that consumers have in using ecological vehicles (Maranguié and Granié, 2014) since they have a different technology from conventional ones. According to the DOI theory, what influences attitude is relative advantage, compatibility, and complexity (Dilotsotlhe and Duh 2021). The relative advantage means that ecological vehicles are perceived as being superior (Dilotsotlhe and Duh 2021). In terms of compatibility, this means that ecological vehicles meet the existing values, previous experiences and needs of potential consumers (Dilotsotlhe and Duh 2021). The complexity has to do with the fact that ecological vehicles are perceived as relatively difficult to understand and use (Dilotsotlhe and Duh 2021).

Therefore, the following hypotheses were formulated:

H1 The perceived utility has a positive effect on attitude.

H2 The perceived easiness has a positive impact on attitude.

H3 The relative advantage has a positive influence on attitude.

H4 The compatibility has a positive influence on attitude.

H5 The complexity has a negative influence on attitude.

The purchase intention of ecological vehicles can be explained through the TPB. Thus, purchase intention is influenced through attitude, subjective norm, and perceived behavioral control (Asadi et al. 2021). Attitude is the consumers' total assessment of the purchase intention of green vehicles (Asadi et al. 2021). The subjective norm concerns what consumers perceive in relation to their behavior regarding the adoption of ecological vehicles from the perspective of the people around them (Asadi et al. 2021). Perceived behavioral control refers to the perceived convenience or difficulty in purchasing an ecological vehicle (Asadi et al. 2021). Additionally, knowledge has an impact on consumer intentions (Lewicki et al. 2021), and is

defined as the consumers knowing the concept of an ecological vehicle and having an interest in this type of vehicle (Bruner 2017).

Therefore, the following hypotheses were formulated:

H6 Attitude has a positive impact on the purchase intention.

H7 Knowledge has a positive impact on the purchase intention.

H8 Subjective norm is positive related to the purchase intention.

H9 The perceived behavior control has a positive relation with the intention of purchase.

Finally, the purchase intention can be explained through personal norms, as explained through the NAM model. In this model, personal norms are influenced by awareness of consequences, attribution of responsibility and consumer effectiveness (Asadi et al. 2021). Awareness of consequences concerns awareness of the fact that traditional vehicles produce unfavorable outcomes, such as environmental pollution and global warming (Asadi et al. 2021). The attribution of responsibility is the individual responsibility for the consequences of using a traditional vehicle (Asadi et al. 2021). Consumer perceived effectiveness is understood as consumer beliefs regarding their role in reducing the undesirable effects of using conventional vehicles, that is, individuals' beliefs in protecting the environment by adopting ecological vehicles (Asadi et al. 2021). Personal norms are the moral commitment felt by individuals in relation to the adoption of ecological vehicles instead of traditional vehicles (Asadi et al. 2021).

Therefore, the following hypotheses were formulated:

H10 Awareness of consequences has a positive impact on personal norms.

H11 Attribution of responsibility has a positive impact on personal norms.

H12 Perceived efficiency of the consumer has a positive relation with personal norms.

H13 Personal norms have a positive impact on the purchase intention.

As already shown by (Dilotsotlhe and Duh 2021; Asadi et al. 2021; Maranguié and Granié 2014) purchase intention often leads to actual behavior, in this case, buying an ecological vehicle.

Methodology

Data collection and analysis

We have obtained the data used in this research through a survey which was developed and available in Google Forms. All the participants had access to a first section of the questionnaire informing about its purpose and objectives. The participants were informed of the confidentiality of their data as the authors do not have access to any identifying information (i.e.: name or e-mail). Moreover, the participants were able to refuse to answer any question, giving their consent to participate in this study previously to answering the questionnaire. The questions performed were developed based on previous studies explored in the literature review. Furthermore, we have validated the questions by performing several tests by different people before launching the questionnaire. The questionnaire was designed to take approximately seven minutes and was structured in eight sections as per Table 1.

The measurement of each variable was also based on previously used measurements. For most questions, the 5-point Likert scale was used, which measure how much the participant agrees with the statement (where 1 corresponds to strongly disagree and 5 to strongly agree) and the remaining questions were yes/no or multiple choice. The questionnaire was shared on social networks, and it was available between November 13, 2021, and March 3, 2022. The study focused on Portuguese residents and had a total of 240 participants. As all the answers were complete and correctly answered, the final sample was also of 240 answers. We have used a simple random sampling design as we have randomly selected a subset of the Portuguese population. When the questionnaire was shared, the authors aimed at obtaining as much diversified answers as possible, which allows an analysis by generation.

To analyze the data the authors have used the R-Studio software, mainly the Lavaan package. First, a descriptive analysis of the sample was carried out—considering the demographic data and the control questions. Then, a comparison was made between generations using econometric models—linear regressions. Finally, a structural equation model was carried out to test the research model and understand which factors lead to the intention to purchase ecological vehicles.

Table 1 Questionnaire structure

Section	Purpose
Section I	Study purpose
Section II	Control Questions
Section III	Factors that influence the attitude
Section IV	Factors that influence the purchase intention
Section V	Factors that influence the personal norms
Section VI	Intention and behavior of consumers
Section VII	Preferable ecological vehicle
Section VIII	Demographic questions

Descriptive statistics

Gender and generation

The sample consists of 240 participants, 159 (66.3%) female, 80 (33.3%) male, and 1 (0.4%) who preferred not to specify. Participants belong to all generations from before Baby Boomers to generation Z. Specifically, 82 participants (34%) belong to generation X, 70 participants (29%) belong to generation Z, 53 participants (22%) belong to generation Millennials, 35 participants (15%) belong to generation Baby Boomers and before.

Monthly gross income and degree

As for income, depicted in Fig. 9, 164 participants receive between €0 and €1.500 gross monthly. When comparing income by generation, generation X is the one with the highest income. The vast majority of Gen Z earn between €0 and €1.500, while most of millennials earn between €1.001 and €1.500 gross monthly.

In our sample, 161 (67%) participants have a high level of education—bachelor's or master's degree. When comparing the level of education with income in Fig. 10, we can see that most graduates receive between €501 and €1.500 and those with a master's degree receive between €1.001 and €1.500.

Ecological vehicle ownership and purchase intention

Regarding the preferred vehicle type as per Fig. 11, only 19 respondents (7.9%) have an ecological vehicle. However, within 5 years 99 (41.2%) participants say they are interested in purchasing this type of vehicle. Regarding the preferred ecological vehicle, the hybrid electric vehicle was chosen by 71 participants, the hydrogen fuel

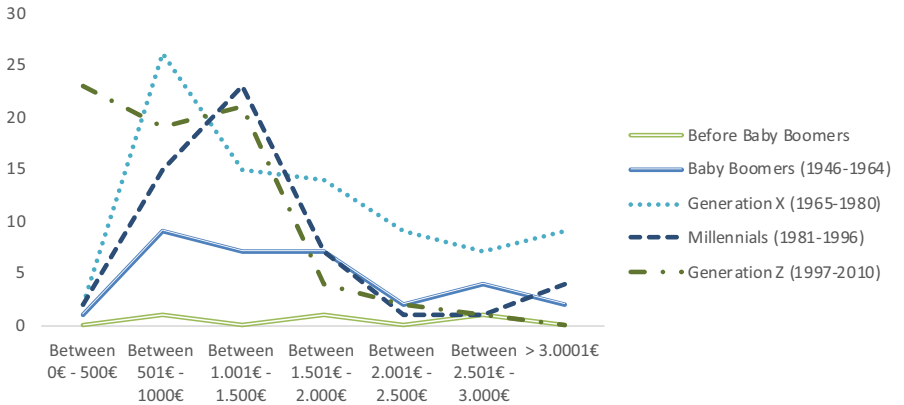

Fig. 9 Gross monthly income per generation

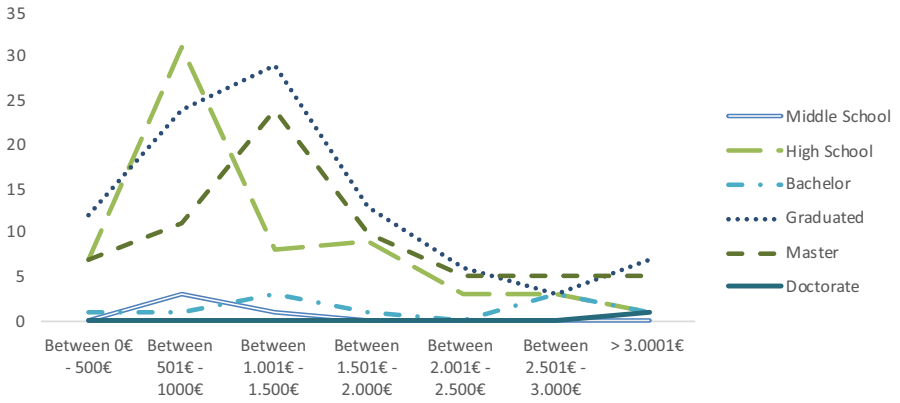

Fig. 10 Income per school degree

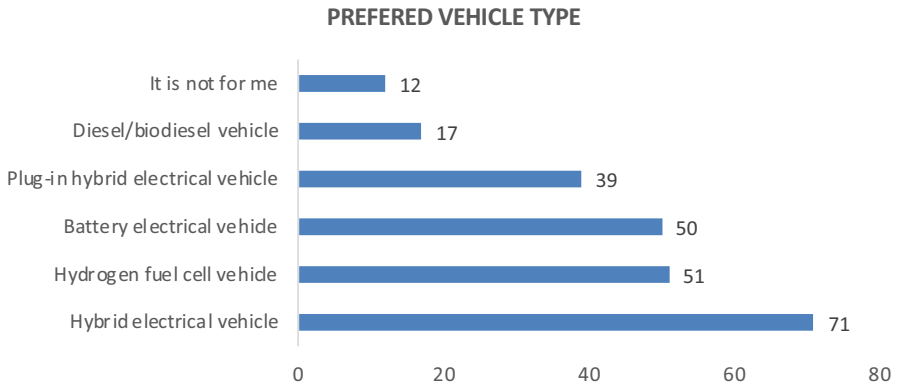

Fig. 11 Preferred ecological vehicle

cell vehicle was chosen by 51 participants and the battery electric vehicle was chosen by 50 participants.

Variables

Participants say that they are familiar with the ecological vehicle concept ($\bar{x}=3.64$) and that these types of vehicles are useful, mainly in ecological terms ($\bar{x}=3.79$). Participants perceive ecological vehicles as being easy to drive ($\bar{x}=3.73$). Additionally, respondents show that ecological vehicles have a relative advantage mainly in reducing pollution ($\bar{x}=3.82$). As for compatibility, participants report that the use of this type of vehicle is in line with their values ($\bar{x}=3.47$). Regarding the complexity of these vehicles, they say that they do not find it difficult to understand how they work in terms of driving ($\bar{x}=2.36$). At the attitude level, the participants demonstrate that if they could choose, they would opt for the ecological version ($\bar{x}=3.48$).

They neither agree nor disagree that the use of ecological vehicles is a social trend ($\bar{x}=3.17$). In addition, participants are aware of the consequences and consider that conventional vehicles are increasing environmental pollution ($\bar{x}=3.88$). Finally, they claim to have a common sense to protect the environment ($\bar{x}=4.00$). Table 2 presents a summary of the most relevant variables under study.

Results

Structural equation model

Validity, reliability, and model fit

Concerning the validity and model fit of the SEM, we have used the mean and Cronbach's α for each variable. Analyzing the average of the variables, we conclude that the participants agree with the statements used to measure each variable. The reliability, referring to the consistency of measure, was measured using Cronbach's α and summarized in Table 3.

The Cronbach's α of all variables is above the recommended (0.70) and varies between 0.70 and 0.72. This indicates that all the measures used have satisfactory internal consistency and the results can be reproduced under the same conditions.

A loadings table, summarized in Table 4, is an important component of a structural equation modeling analysis, as it provides information about the strength and direction of the relationship between each observed variable and its underlying factor. The table is organized with observed variables as rows and factors as columns, and each cell displays the factor loading for a given variable. The factor loading represents the correlation between the observed variable and the underlying factor and indicates how well that variable is explained by the factor. Our table displays high factor loadings indicating that the observed variable is strongly related to the underlying factor.

Loadings are above 0.3 and even 0.5

Table 2 Descriptive statistics

Variable	Mean	Median	Minimum	Maximum
Knowledge	3.64	4	1	5
Utility	3.79	4	1	5
Easiness	3.73	4	1	5
Relative advantage	3.82	4	1	5
Compatibility	3.47	4	1	5
Complexity	2.36	2	1	5
Attitude	3.48	4	1	5
Subjective norm	3.17	3	1	5
Awareness of the consequences	3.88	4	1	5
Personal norm	4.00	4	1	5

Table 3 Mean and validity

Variable	Mean	Cronbach's α
Utility	3.37	0.71
Easiness	3.37	0.71
Relative advantage	3.75	0.70
Compatibility	3.29	0.70
Complexity	2.69	0.72
Attitude	3.48	0.70
Knowledge	3.34	0.71
Subjective norm	2.99	0.71
Perceived behavior control	3.61	0.70
Awareness of the consequences	3.78	0.71
Attribution of responsibility	3.23	0.71
Perceive effectiveness	2.76	0.72
Personal norm	3.60	0.72
Purchase intention	3.25	0.70

Contrarily to traditional linear regression model, the *R*-squared measure is not a commonly used fit statistic for SEM. Therefore, SEM models estimate relationships among multiple latent variables, which are not directly observable, making it difficult to compute *R*-squared. We have used the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR) instead. The RMSEA is 0.072 (<0.08) and the SRMR is 0.075 (<0.08), indicating that the model has a good fit. On the contrary, the model showed some drawbacks concerning residuals and homoscedasticity. We have performed a Ljung–Box test, for independence of residuals and a Shapiro–Wilk test for normality. Furthermore, we have performed the Breusch–Pagan test for homoscedasticity. We have rejected the null hypothesis confirming that the model has the previously mentioned limitations. Therefore, we have performed a robust SEM using the method Weighted Least Squares with Mean and Variance correction (WLSMV) available in R-Studio. WLSMV is a robust estimation method that adjusts for non-normality in the data and corrects for unequal variances in the residuals of the model. The method involves weighting each data point based on its standardized residual. The weights are chosen in a way that gives more emphasis to observations that are less likely to deviate from the model's prediction, thus reducing the influence of outliers on the estimates. WLSMV also accounts for the mean and variance correction of the data, ensuring that the model accurately reflects the distribution of the data. This method is particularly useful when the data deviates from normality and when the variances of the residuals are unequal, as it provides more robust and accurate estimates in these cases.

Econometric models

Having used the purchase intention as our dependent variable for the econometric models summarized in Table 5, we confirmed that knowledge (p value = 0.018),

Table 4 Loadings table

	Knowledge	Utility	Ease	Advantage	Compatibility	Complexity	Attitude	Subjective	Control	Consequences	Responsibility	Efficiency	Personal	Purchase
C1	0.68	0	0	0	0	0	0	0	0	0	0	0	0	0
C2	0.85	0	0	0	0	0	0	0	0	0	0	0	0	0
U1	0	0.82	0	0	0	0	0	0	0	0	0	0	0	0
U2	0	0.67	0	0	0	0	0	0	0	0	0	0	0	0
U3	0	0.83	0	0	0	0	0	0	0	0	0	0	0	0
U4	0	0.91	0	0	0	0	0	0	0	0	0	0	0	0
F1	0	0	0.55	0	0	0	0	0	0	0	0	0	0	0
F2	0	0	0.85	0	0	0	0	0	0	0	0	0	0	0
F3	0	0	0.93	0	0	0	0	0	0	0	0	0	0	0
V1	0	0	0	0.90	0	0	0	0	0	0	0	0	0	0
V2	0	0	0	0.90	0	0	0	0	0	0	0	0	0	0
COMPAT1	0	0	0	0	0.86	0	0	0	0	0	0	0	0	0
COMPAT2	0	0	0	0	0.49	0	0	0	0	0	0	0	0	0
COMPAT3	0	0	0	0	0.83	0	0	0	0	0	0	0	0	0
COMPLEX1	0	0	0	0	0	0.36	0	0	0	0	0	0	0	0
COMPLEX2	0	0	0	0	0	0.99	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0	0.83	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0.90	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0.86	0	0	0	0	0	0	0
NS1	0	0	0	0	0	0	0	0.63	0	0	0	0	0	0
NS2	0	0	0	0	0	0	0	0.91	0	0	0	0	0	0
NS3	0	0	0	0	0	0	0	0.92	0	0	0	0	0	0
NS4	0	0	0	0	0	0	0	0.47	0	0	0	0	0	0

Table 4 (continued)

	Knowledge	Utility	Ease	Advantage	Compatibility	Complexity	Attitude	Subjective	Control	Consequences	Responsibility	Efficiency	Personal	Purchase
CCP1	0	0	0	0	0	0	0	0	1.00	0	0	0	0	0
CC1	0	0	0	0	0	0	0	0	0	0.86	0	0	0	0
CC2	0	0	0	0	0	0	0	0	0	0.90	0	0	0	0
CC3	0	0	0	0	0	0	0	0	0	0.86	0	0	0	0
AR1	0	0	0	0	0	0	0	0	0	0	0.99	0	0	0
AR2	0	0	0	0	0	0	0	0	0	0	0.94	0	0	0
EP1	0	0	0	0	0	0	0	0	0	0	0	1.00	0	0
NP1	0	0	0	0	0	0	0	0	0	0	0	0	0.69	0
NP2	0	0	0	0	0	0	0	0	0	0	0	0	0.73	0
IC1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.90
IC2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.87
COMP1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.83

Table 5 Econometric models and comparison between generations

	Base model			Baby boomers and before			Generation X			Millennials			Generation Z		
	Coef-ficients	*P* values	Standard errors	Coef-ficients	*P* values	Standard errors	Coef-ficients	*P* values	Standard errors	Coef-ficients	*P* values	Standard errors	Coef-ficients	*P* values	Standard errors
Knowledge	0.137	0.018**	0.058	0.255	0.363	0.273	0.104	0.366	0.114	− 0.115	0.383	0.131	0.037	0.722	0.103
Utility	− 0.031	0.683	0.076	0.03	0.909	0.257	− 0.027	0.859	0.151	− 0.063	0.731	0.181	− 0.032	0.83	0.148
Easiness	0.054	0.338	0.056	− 0.387	0.358	0.41	0.114	0.282	0.105	− 0.003	0.979	0.12	0.067	0.513	0.101
Advantage	0.063	0.412	0.077	0.136	0.693	0.338	0.081	0.595	0.151	0.019	0.906	0.155	0.304	0.045**	0.148
Compat-ibility	0.103	0.175	0.076	0.249	0.346	0.257	0.04	0.799	0.156	0.307	0.108	0.187	− 0.112	0.348	0.129
Complex-ity	− 0.036	0.428	0.046	− 0.251	0.320	0.245	− 0.073	0.342	0.077	0.089	0.373	0.099	0.032	0.745	0.098
Attitude	0.048	0.561	0.083	0.23	0.512	0.342	0.376	0.018**	0.154	0.007	0.97	0.182	− 0.349	0.031**	0.158
Subjective norm	0.096	0.237	0.081	− 0.471	0.254	0.399	0.055	0.734	0.162	0.29	0.173	0.209	0.126	0.347	0.133
Behavioral control	0.133	0.063*	0.072	0.582	0.109	0.345	0.056	0.674	0.132	0.311	0.052*	0.155	0.156	0.253	0.135
Conse-quences	0.081	0.210	0.065	0.168	0.455	0.219	− 0.001	0.991	0.127	0.06	0.678	0.143	0.036	0.768	0.122
Responsi-bility	0.113	0.060*	0.06	0.213	0.400	0.247	0.076	0.494	0.111	− 0.079	0.665	0.181	0.328	0.004**	0.109
Effective-ness	0.163	0.011**	0.063	0.34	0.202	0.256	0.175	0.097*	0.104	0.269	0.085*	0.152	0.197	0.15	0.135
Personal norm	0.137	0.012**	0.054	− 0.076	0.725	0.214	0.11	0.289	0.103	0.14	0.232	0.115	0.198	0.050**	0.099
Age	0.005	0.177	0.004												

***0.001; **0.05, *0.1

behavioral control (p value = 0.063), responsibility (p value = 0.060), effectiveness (p value = 0.011) and personal norm (p value = 0.012) are statistically significant for our base model. The residual standard error is 0.732, the R-square is 0.6096, and the F-statistic is 29.54 with a p value of $2.2e^{\wedge(-16)}$ which indicate a good fit.

According to the theoretical models, there are variables that influence attitude and others that influence personal norms. Therefore, we tried to understand if the same holds true in our sample. In separate regressions, we confirmed that the utility (p value = 0.009), the advantages (p value = $2.84e^{\wedge(-6)}$) and the compatibility (p value = $1.14e^{\wedge(-7)}$) are the variables that influencing attitude. The most significant variables that influence personal norms are the attribution of responsibility (p value = $4.89e^{\wedge(-6)}$) and perceived effectiveness (p value = $1.76e^{\wedge(-5)}$).

Moreover, we studied whether there were differences between generations (i.e.: the variable age was used as a proxy for generation) regarding the intention to purchase ecological vehicles and we can conclude that this is not the case (p value = 0.177). However, performing regressions restricting the sample per generation, allowed us to conclude that different generations value different aspects. Starting with baby boomers and before them, none of the variables is considered significant. In generation X, attitude and effectiveness are statistically significant variables. In Millennials, behavioral control and effectiveness are statistically significant variables. In generation Z, advantages, attitude, responsibility, and personal norm are statistically significant variables. It should be noted that in Generation Z, attitude negatively influences purchase intention, that is, even if participants prefer to opt for an ecological vehicle over a conventional one it does not mean that they have the intention to purchase. It can be explained that, despite considering the ecological option, it may have negative characteristics that lead to a less positive attitude towards this option and hence affect the purchase intention.

Test of research hypotheses

The results of the pathway analysis in Fig. 12 show that attitude is positively and significantly explained by relative advantage ($\beta = 0.365$; z value = 2.233; p value = 0.026), compatibility ($\beta = 0.329$; z value = 2.182; p value = 0.029) and complexity ($\beta = 1.684$; z value = 2.692; p value = 0.007), thus, hypothesis H3, H4 and H5 are supported. On the other hand, perceived usefulness ($\beta = 0.028$; z value = 0.150; p value = 0.881) and ease of use ($\beta = -0.754$; z value = − 3.455; $p = 0.001$) do not influence the attitude of consumers. Therefore, hypothesis H1 and H2 are not supported.

Additionally, awareness of consequences ($\beta = -0.453$; z value = − 2.454; p value = 0.014) and the attribution of responsibility ($\beta = 0.107$; z value = 1.556; p value = 0.12) did not influence personal norms, then hypotheses H10 and H11 are not supported. In contrast, perceived effectiveness ($\beta = 0.979$; z value = 4.246; p value = 0.000) positively and significantly influences personal norms, therefore, hypothesis H12 is supported.

Attitude ($\beta = 0.435$; z value = 2.739; p value = 0.006) and personal norm ($\beta = 0.796$; z value = 4.129; $p = 0.000$) positively and significantly influence consumers' purchase intention, thus, hypotheses H6 and H13 are supported. On the

contrary, knowledge ($\beta = 0.180$; z value $= 1.724$; p value $= 0.085$), the subjective norm ($\beta = 0.012$; z value $= 0.116$; p value $= 0.908$) and perceived behavior control ($\beta = 0.055$; z value $= 0.065$; p value $= 0.394$) have no effect on the intention to purchase ecological vehicles. In this case, hypotheses H7, H8 and H9 are not supported. Table 5 presents the summary of the analysis of the model under study.

Discussion

The present research model is a combination of several theories and models such as TAM, DOI, NAM and TPB. Therefore, the proposed model studies the main factors that influence the purchase intention of ecological vehicles in Portugal. The results summarized in Table 6 indicate that there are significant effects between personal norms and the intention to purchase environmentally friendly vehicles. Previous studies also support this result and consider personal norms as one the biggest predictors of purchase intention for environmentally friendly behaviors (Asadi et al. 2021). Particularly, those who have greater social concerns are those who will have more pro-environmental behaviors. Understanding this type of vehicles is essential for the intention to purchase them.

In this study, perceived effectiveness is positively and significantly associated with personal norms, supporting the NAM theory. Which means that the fact that ecological vehicles help to combat the scarcity of resources and the fact that individuals think about environmental protection leads to the idea that ecological vehicles are more efficient environmentally. Consumers' perception of their potential to influence through ecological vehicles leads to greater motivation to help against environmental pollution through personal norms.

Attitude is influenced by advantages, compatibility, and complexity. This is in line with the results of the study by Dilotsotlhe and Duh (2021). Additionally, it supports what is explained in DOI theory. Individuals consider that these types of vehicles are advantageous in environmental terms to form positive attitude towards ecological vehicles. Next, when green vehicles do not differ from conventional vehicles (compatibility), consumers will favorably evaluate green vehicles. Finally, they do not find driving an ecological vehicle frustrating or difficult, which contributes to a positive attitude towards them. This suggest that ecological vehicles should be kept as simple as possible if they want to have positive attitudes towards them (Dilotsotlhe and Duh 2021).

Purchase intention is positively and significantly influenced by consumers' attitude. Also, as shown in the studies by Asadi et al. (2021) and Vafaei-Zadeh et al., (2022). Specifically, the positive attitude towards this type of vehicles, as they are environmentally friendly and in line with the participants' value, influences the purchase intention of ecological vehicles.

Moreover, the variable that most affects purchase intention is related to personal norms. That is, individuals have a moral commitment to adopting ecological vehicles instead of conventional ones, which is essentially due to consumer beliefs regarding their role in reducing the undesirable effects of using conventional

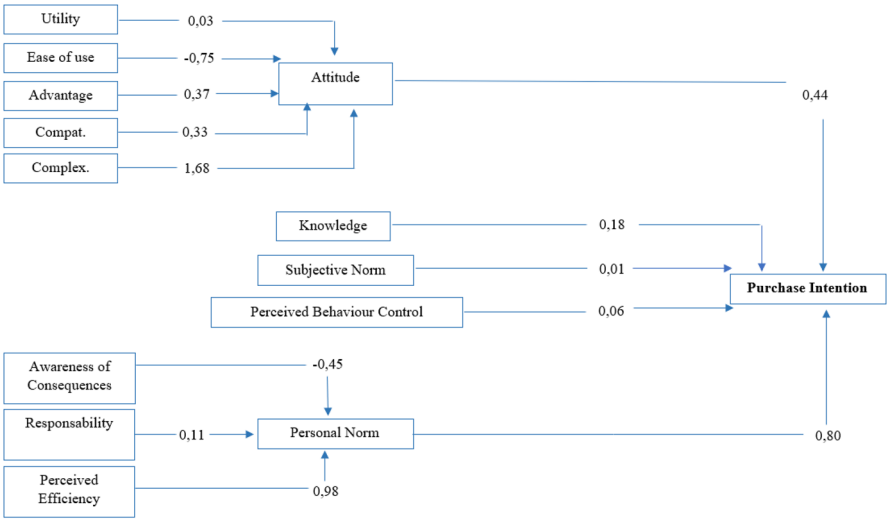

Fig. 12 Conceptual model

vehicles, meaning, their beliefs in protecting the environment by adopting an ecological variable. The other variable that most affects purchase intention is attitude, consistent with the results of the study by Huang and Ge (2019) as they perceive ecological vehicles as being superior (relative advantage). In addition, this type of vehicles meets existing values, previous experiences, and consumer needs and because they do not understand ecological vehicles as difficult to use, in line with the findings of Tu and Yang (2019).

Contrary to what would be expected, knowledge, subjective norms and perceived behavior control do not influence the purchase intention of these consumers. In this case, the TPB is not verified, which leads us to consider that, although consumers have knowledge about this type of vehicle, it is not enough to have the purchase intention. Second, as the subjective norm has no impact on purchase intentions, meaning that consumers are not influenced by the perspective of the people around them. This evidence is also found in studies by Moons and Pelsmacker (2015) and Huang and Ge (2019). Finally, the convenience and ease of purchasing this type of vehicle (perceived behavior control) do not influence the purchase intention, meaning that, even if there are stands with this type of vehicle and/or charging stations, this has no impact on the purchase intention of ecological vehicles.

Finally, there was no impact verified concerning generations, that is, belonging to a given generation does not mean that these consumers are more likely to have a greater intention to purchase ecological vehicles. However, it was found that different generations value different factors. In other words, marketing strategies should consider the target audience of each generation, given that different generations consider different factors to be relevant.

Table 6 Conceptual model analysis summary

Variable	Coefficient	*Z* value	*P* value	Result
Utility → Attitude	0.028	0.150	0.881	Not supported
Easiness of use → Attitude	− 0.754	− 3.455	0.001	Not supported
Advantage → Attitude	0.365	2.233	0.026	Supported
Compatibility → Attitude	0.329	2.182	0.029	Supported
Complexity → Attitude	1.684	2.692	0.007	Supported
Awareness of the consequences → Personal norm	− 0.453	− 2.454	0.014	Not supported
Responsibility → Personal norm	0.107	1.556	0.120	Not supported
Perceived efficiency → Personal norm	0.979	4.246	0.000	Supported
Knowledge → Purchase intention	0.180	1.724	0.085	Not supported
Attitude → Purchase intention	0.435	2.739	0.006	Supported
Subjective norm → Purchase intention	0.012	0.116	0.908	Not supported
Perceived behavior control → Purchase intention	0.055	0.065	0.394	Not supported
Personal norm → Purchase intention	0.796	4.129	0.000	Supported

Conclusions

Main conclusions

The main objective of this research was to develop a model and investigate potential factors that affect the purchase intention of ecological vehicles among the Portuguese consumers. We also aimed at understanding whether the fact of belonging to a given generation had any significant impact on the purchase intention. One of the main advantages of this study is that it is extended to all ecological vehicles and not only to electric vehicles, as is the case of most studies.

The investigation model was performed according to TAM, TPB, DOI and NAM. To develop our model and to acquire data, a questionnaire was carried out to the Portuguese population. Of the thirteen research hypotheses, only six were supported and considered to be those that affect consumers' intention to purchase ecological vehicles. Thus, the variables that most affect the attitude of consumers are relative advantages, compatibility, and complexity. The variable that affects personal norms is perceived effectiveness. Finally, the variables that significantly affect purchase intention are attitude and personal norms.

Among the various options for ecological vehicles, the preferred one by participants is the hybrid electric vehicle, and they also consider the hydrogen-powered vehicle as one of the potential options for a future purchase.

When we compare generations, we conclude that there are no significant effects on purchase intention. However, different generations value different variables. In sum, marketing campaigns must consider the different variables that most affect purchase intention, to effectively reach their target audience. Furthermore, they must show how simple these vehicles are compared to conventional ones, and their advantages, specifically in terms of environmental impact.

Limitations and recommendations for future research

This study has some limitations. First, the purchase intention of consumers in relation to ecological vehicles was studied. And while it is possible to predict actual behavior through purchase intent, it does not always mean that having purchase intention leads to purchase. In this sense, more research should be carried out to predict the real behavior of Portuguese consumers in relation to the purchase of ecological vehicles. A comparative analysis can also be carried out in other markets for example in Europe.

On the other hand, this study was based on TAM, TPB, DOI and NAM. Future studies may incorporate other theories such as the S–O–R model, risk–benefit models, agent-based-model (ABM) and theory of consumption values.

Additionally, this study was carried out during the COVID-19 pandemic, which has influenced the global economy. So, what impact will it have on the green vehicle industry? Some factors may affect the choice of means of transport. Consumers may want to avoid mass transportation as it may increase contact with other people (Song et al. 2021). In addition, consumers are experiencing an improvement in air quality, and this may motivate them to opt for this type of vehicle (Song et al. 2021). Tesla's rapid growth, coupled with COVID-10 pandemic, could be a sign of growth in the electric vehicle market, a field experiment could be useful to understand the impact of COVID-19 on the purchase of electric vehicles.

As an example, another possible study would be to measure the environmental impacts of different vehicles. In this sense, understand from production to use which eco-vehicle is the most sustainable.

Finally, this study focused only on the Portuguese population, where this type of vehicle has been growing exponentially. Therefore, these results may not be generalized to another context. More research is needed to examine and confirm our results in the context of other countries. Additionally, future researchers will be able to apply other data analysis methods such as machine learning and multi-criteria decision making to investigate ecological vehicles and make comparisons to introduce these vehicles more strongly.

Contributions for theory and implications for practice

The fact that it is a study focused on ecological vehicles is important to understand the purchase intention of consumers, mainly because it is part of an important industry that an impact on environmental pollution. In addition, it is a study restricted to Portuguese consumers, where the demand for this type of vehicle has been growing and where are few studies regarding consumer behavior in relation to this type of vehicle.

When comparing generations, we realized that different generations have different significant variables influencing purchase intention, which leads to the conclusion that different factors influence the purchase decision towards different generations, thus contributing to make into account future marketing campaigns.

Incorporating several theories, the present investigation supports the NAM and DOI theories, that is, the variables that affect the purchase intention are attitude and personal norms. For consumers to form a positive attitude, the relative advantages of this type of vehicle must remain simple and must not differ from conventional vehicles. Additionally, the influence that ecological vehicles have on the environment must be shown to help against environmental pollution. Consumers are more concerned with the influence of their attitudes towards the environment than their social status.

By studying the preferred vehicle and the interest in hydrogen powered vehicles, we were able to provide ideas for the market as well as for the continued development of this type of vehicles (mainly hybrid electric vehicles and hydrogen powered vehicles) in the Portuguese market. More specifically, hydrogen powered vehicles are starting to enter the market in Portugal (Hyundai Portugal 2021). In this sense, the offer of this type of vehicle should increase, as well as the charging points for hydrogen vehicles. In addition, marketing campaign for these vehicles should focus on their environmental benefits as well as ease of loading. As for hybrid electric vehicles, given they are preferable, vehicle companies that have this type of vehicles in Portugal should focus on promoting them more consistently.

Acknowledgements The author José Campino acknowledges the financial support of Fundação para a Ciência e Tecnologia through the project number PTDC/EGE-ECO/7493/2020.

Authors' contributions JC coordinated the research and developed the computer code for data analysis. FM analyzed the literature and developed the conceptual models. She also analyzed the data. AR reviewed the entire work and provided insights for improvement.

Funding Open access funding provided by FCT|FCCN (b-on). No funding was received for conducting this study.

Availability of data and material The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Conflict of interests The authors declare that they have no competing interests.

Ethical statement Informed consent was obtained from all participants.

Consent for publication Not applicable.

References

Ajzen I (1991) Attitudes, personality, and behavior, 2nd edn. Open University Press/McGraw-Hill, Milton-Keynes, p 4

Asadi S, Nilashi M, Samad S, Abdullah R, Mahmoud MM, Alkinani MH, Yadegaridehkordi E (2021) Factors impacting consumers' intention toward adoption of electric vehicles in Malaysia. J Cleaner Prod 282:124474. https://doi.org/10.1016/j.jclepro.2020.124474

Baskar S, Vijayan V, Premkumar IJ, Arunkumar D, Thamaran D (2020) Design and material characteristics of hybrid electric vehicle. Mater Today Proc. https://doi.org/10.1016/j.matpr.2020.05.352

BMW (2020) Hydrogen fuel cell cars: everything you need to know. https://www.bmw.com/en/innovation/how-hydrogen-fuel-cell-cars-work.html

Bridi RM, Alhosani N (2021) Theoretical reflections on consumer behavior: the adoption and non-adoption of electric vehicles. https://doi.org/10.1109/icrega50506.2021.9388315

Bruner GC (2017) Marketing scales handbook: multi-item measures for consumer insight research, vol 9

CGD (2021) Qual o incentivo fiscal para cmprar carros sutentáveis em 2021. https://www.cgd.pt/Site/Saldo-Positivo/mobilidade/Pages/incentivo-fiscal-carros-sustentaveis.aspx

Correia R (2021) Veículos elétricos já compõem 7.5% da quota de mercado europeia de novos carros. Sustentável. In: Revista Sustentável. https://www.revistasustentavel.pt/

Cruz CO, Costa Á, Sarmento JM, Sousa VF, Januário JF (2021) Sistemas de Transportes em Portugal. Fundação Francisco Manuel dos Santos

De Groot J, Steg L (2007) General beliefs and the theory of planned behaviour: the role of environmental concerns in the TPB. J Appl Soc Psychol 37:1817–1836

DECO (2021) Carros elétricos: apoios à compra e condições. https://www.deco.proteste.pt/auto/automoveis/noticias/carros-eletricos-apoios-compra-condicoes/incentivo-do-governo

Degrimenci K, Breitner M (2017) Consumer purchase intentions for electric vehices: Is green more important than price and range? Transp Res Part D 51:250–260

Dilotsotlhe N, Duh H (2021) Drivers of middle-class consumer's green applicance attitude and purchase behavior: a multi-theory application. Soc Mark Q 27:150–171

EAMA (2020) Electric vehicles: tax benefits and purchase incentives. https://www.acea.auto/files/Electric_vehicles-Tax_benefits_purchase_incentives_European_Union_2020.pdf

EEA (2022) Decarbonising road transport—the role ofvehicles, fuels and transport demand. https://www.eea.europa.eu/publications/transport-and-environment-report-2021

Ekonomista (2020) Carros Ecológicos: os benefícios de uma realidade incontornável. https://blueacademy.hyundai.pt/artigo/beneficios-carros-ecologicos/

Featherman M, Jia S, Galiff C, Hajli N (2021) The impact of new technologies on consumers beliefs: reducing the perceived risks of electric vehicles adoption. Technol Forecast Soc Chang 169:1–18

Goldsmith R, Lafferty B, Newell S (2000) The impact of corporate credibility and celebrity credibility on consumer reaction to advertisments and brands. J Advert 29:43–54

Hoyer W, MacInnis D, Pieters R (2012) Consumer behavior. South-Western CENAGE Learning, USA

Huang X, Ge J (2019) Electric Vehicle development in Beijing: An analysis of consumer purchase intention. J Clean Prod 216:361–372

Hyundai Portugal (2021) O futuro dos carros a hidrogénio em Portugal. https://blueacademy.hyundai.pt/artigo/futuro-carros-hidrogenio-portugal

IEA (2021) Tracking transport 2021, IEA, Paris. https://www.iea.org/reports/tracking-transport-2021

Jahns K (2021) The environment is Gen Z's No.1 concern - and some companies are taking advantage of that. https://www.cnbc.com/2021/08/10/the-environment-is-gen-zs-no-1-concern-but-beware-of-greenwashing.html

Khazaei H (2019) The influence of personal innovativeness and price value on intention to use of electric vehicles in Malaysia. Online J Nat Soc Sci 8:483–494

Lashari Z, Ko J, Jang J (2021) Consumers' intention to purchase electric vehicles: influences of user attitude and perception. Sustainability 13:1–14

Lewicki W, Drozdz W, Wróblewski P, Zarma K (2021) The road of electromobility in Poland: consumer attitude assessment. Eur Res Stud J 24:28–39

Li W, Long R, Chen H, Geng J (2017) A review of factors influencing consumer intentions to adopt battery electric vehicles. Renew Sustain Energy Rev 78:318–328

Lim X (2021) Millions of electric car batteries will retire in the next decade. What happens to them? https://www.theguardian.com/environment/2021/aug/20/electric-car-batteries-what-happens-to-them

Liu YZO, Cheng P (2019) Predicting consumers' adoption of electric vehicles during the city smog crisis: an application of the protective action decision model. J Environ Psychol 64:30–38
Maranguié N, Granié A (2014) Technology acceptance model: a literature review from 1986 to 2013. Technology acceptance model: a literature review from 1986 to 2013, 14, 81–95
Melo P (2016) Classificação de Veículos Híbridos - Evolução Crescente do Grau de Electrificação. Neutro à Terra, 17. https://parc.ipp.pt/index.php/neutroaterra/article/view/461
Moon H, Park S, Woo J (2021) Staying on convention or leapfrogging to eco-innovation?: Identifying early adopters of hydrogen-power vehicles. Technol Forecast Soc Chang 171:1–11
Moons I, Pelsmacker P (2012) Emotions as determinants of electric car usage intention. J Mark Manag 28:195–237
Moons I, Pelsmacker P (2015) An extended decomposed theory of planned behavior to predict the usage intention of the electric car: a multi-group comparison. MDPI 7:1–34
Paiva R (2019) As alterações climáticas são o que mais preocupa a Geração Z. https://www.publico.pt/2019/12/10/p3/noticia/alteracoes-climaticas-sao-preocupa-geracao-z-1896682
Peters A, Dütschke E (2014) How do consumers perceive electric vehicles? A comparison of German consumer groups. J Environ Policy Planning 16(3):359–377. https://doi.org/10.1080/1523908x.2013.879037
Petro G (2021) Gen Z is emerging as the sustainability generation. https://www.forbes.com/sites/gregpetro/2021/04/30/gen-z-is-emerging-as-the-sustainability-generation/?sh=713cf34f8699
Pilkington B (2019) The different types of eco cars. https://www.azocleantech.com/article.aspx?ArticleID=958
Rahahleh A, Moflih M, Alabaddi Z, Al-Nsour S (2020) The moderating effect of psychological factors on consumer of electric and hybrid vehicles' response purchase decisions. Manage Sci Lett 10:1649–1658. https://doi.org/10.5267/j.msl.2020.1.015
Rezvani Z, Jansson J, Bodin J (2015) Advances in consumer electric vehicles adoption research: a review and research agenda. Transp Res Part D 34:122–136
Rodrigues R, Albuquerque V, Ferreira J, Dias M, Martins A (2021) Mining electric vehicles adoption of users. World Electr Vehicle J 12:233–264
Sang Y, Bekhet H (2015) Exploring factors influencing eletric vehicle usage intention: an empirical study in malaysia. Int J Business Soc 16:57–74
Saunders M, Lewis P, Thornhill A (2019) Research methods for business students. Pearson
Shin J, Hwang W, Choi H (2019) Can hydrogen fuel vehciles be a sustainable alternative on vehicle market? Comparison of electric and hydrogen fuel cell vehicles. Technol Forecast Soc Chang 143:239–248
Simsekoglu O, Nayum A (2018) Predictors of intention to buy a battery electric vehicle among conventional car drivers. Transp Res Part F 60:1–10
Singh H, Ambikapathy A, Logavani K, Prasad GA, Thangavel S (2021) Plug-in hybrid electric vehicles (PHEVs). https://www.springerprofessional.de/en/plug-in-hybrid-electric-vehicles-phevs/18627048
Skippon S, Kinnear N, Lloyd L, Stannard J (2016) How experience of use influences mass-market drivers' willingness to consider a battery electric vehicle: a randomised controlled trial. Transp Res Part A Pol Pract 92:26–42
Sniehotta F (2009) An experimental test of the theory of planned behavior. Em F. Sniehotta. Appl Psychol Health Well-Being 1:257–270
Song M, Chu W, Im M (2021) The effect of cultural and psychological characteristics on the purchase and satisfaction of electric vehicles: a comparative study of US and China. Int J Consum Stud 46:1–20
TOYOTA (2021) Why we make eco cars. https://www.toyota.co.jp/en/kids/eco/eco.html
Tu J, Yang C (2019) Key factors influencing consumers' purchase of electric vehicles. Sustainability 11:1–22
USEPA (2022) Learn about green vehicles: what makes a vehicle green? https://www.epa.gov/greenvehicles/learn-about-green-vehicles
Vafaei-Zadeh A, Wong T, Hanifah H, Teoh A, Nawaser K (2022) Modelling electric vehicle purchase intention among generation Y consumers in Malaysia. Res Transp Bus Manag 43:1–13
Wu J, Liao H, Wang J, Chen T (2019) The role of environmental concern in the public acceptance of autonomous electric vehicles: a survey from China. Transport Res Part F Traffic Psychol Behav 60:37–46
Xu G, Wang S, Li J, Zhao D (2020) Moving towards sustainable purchase behavior: examining the determinants of consumers' intentions to adopt electric vehicles. Environ Sci Pollut Res 27:22535–22546. https://doi.org/10.1007/s11356-020-08835-9
Zhang X, Bai X, Shang J (2018) Is subsidized electric vehicles adoption sustainable: consumers' perceptions and motivation toward incentive policies, environmental benefits, and risks. J Clean Prod 192:71–79

Authors and Affiliations

José Campino[1] · Francisca Pereira Mendes[2] · Álvaro Rosa[2]

✉ José Campino
josepedrocampino@gmail.com

Francisca Pereira Mendes
francisca.pm.mendes@gmail.com

Álvaro Rosa
alvaro.rosa@iscte-iul.pt

[1] Nova School of Business and Economics, Lisbon, Portugal

[2] ISCTE Instituto Universitário de Lisboa, Lisbon, Portugal