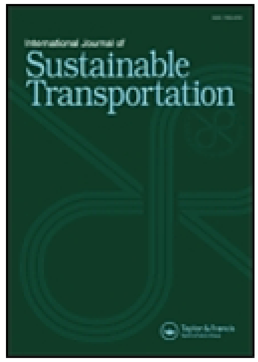

ADOPTION OF ELECTRIC VEHICLES: WHICH FACTORS ARE REALLY IMPORTANT?

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Keywords:	electric vehicles adoption, computational intelligence, consumer behavior, expert interviews

Figure 1 - Factors to be analyzed.

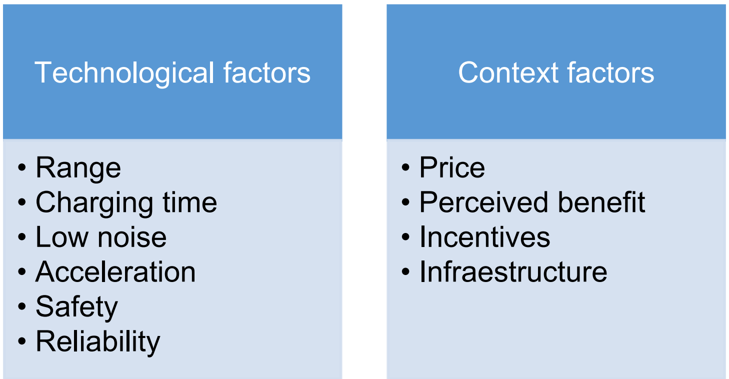

Figure 2 - Selected variables.

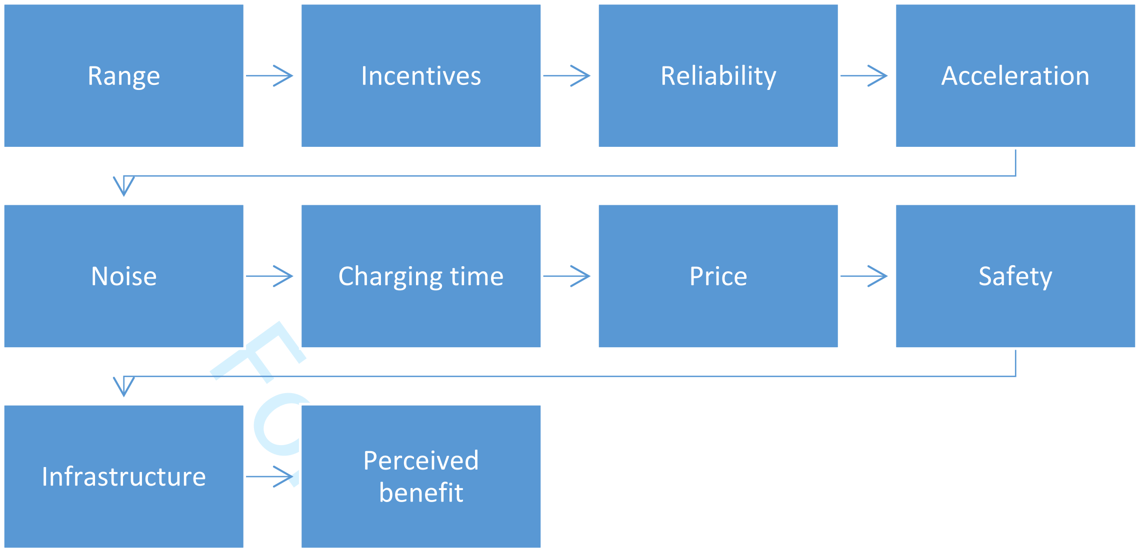

Figure 3 - Performance of the ranking obtained

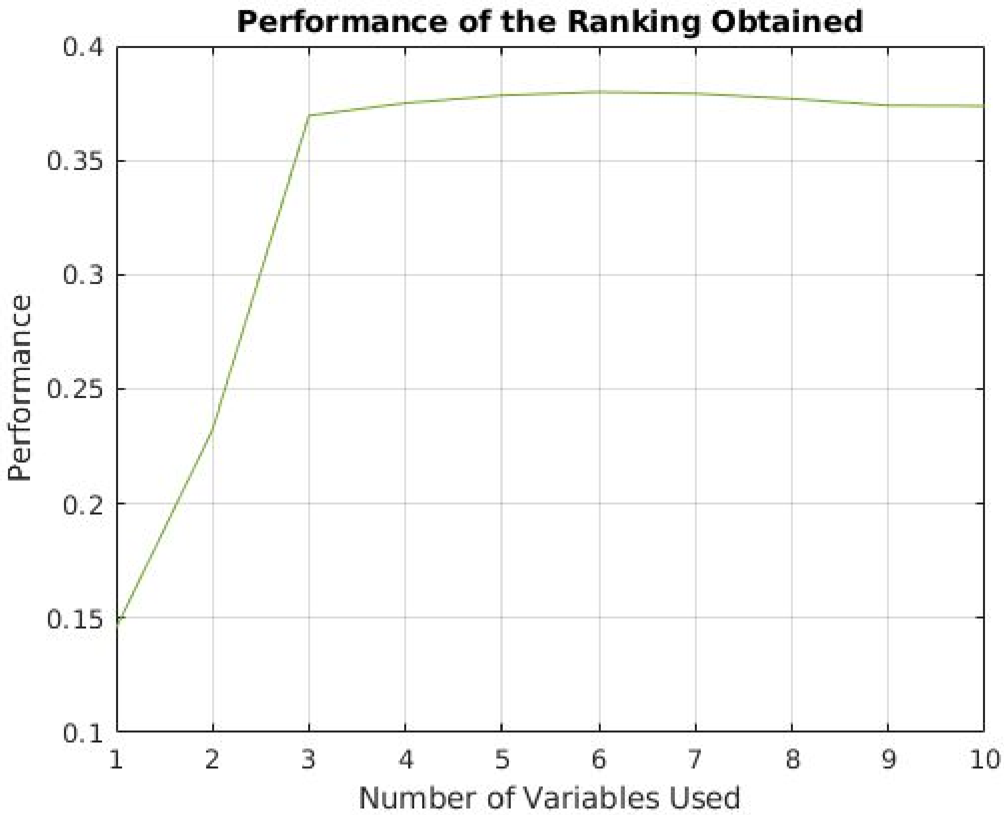

Table 1- Characteristics of the simple.

Gender	Number	Percentage	Monthly income	Number	Percentage
Female	206	51.0	No income	37	9.2
Male	198	49.0	Less than € 1,100	73	18.1
Age bracket			From € 1,100 to € 1,800	135	33.4
18-25	55	13.6	From € 1,800 to € 2,700	95	23.5
26-35	111	27.5	More than € 2,700	40	9.9
36-45	77	19.1	Don't know/No answer	24	5.9
46-55	74	18.3	**Experience as a driver**		
56-65	56	13.9	0-1 year	27	6.7
More than 65	31	7.7	1-3 years	34	8.4
Education			3-5 years	32	7.9
Compulsory or less	21	5.2	5-8 years	207	51.2
Professional training	114	28.2	More than 8 years	104	25.7
Bachelor's degree	178	44.1	**Annual distance driven (Km)**		
Postgraduate degrees	91	22.5	Up to 2,500	78	19.3
Employment status			Up to 7,500	77	19.1
Unemployed	37	9.2	Up to 12,500	75	18.6
Student	43	10.6	Up to 15,000	57	14.1
Regular employed	237	58.7	Up to 20,000	64	15.8
Self-employed	39	9.7	Up to 32,500	31	7.7
Retired	48	11.9	More than 32,500	21	5.2

Table 2 - Expert evaluations.

	SELECTED VARIABLES			
MARKETING AND MARKET RESEARCH	**OPTION 1**	**OPTION 2**	**OPTION 3**	**OPTION 4**
	4	**4,1**	**4,10,6**	**4,10,6,1**
EXPERT 1	5	5	6	6
EXPERT 2	4	5	6	6
EXPERT 3	5	6	7	7
EXPERT 4	3	6	6	7
EXPERT 5	4	6	7	7
MEAN	**4,2**	**5,6**	**6,4**	**6,6**
PROFESSIONALS FROM THE AUTOMOBILE SECTOR	**OPTION 1**	**OPTION 2**	**OPTION 3**	**OPTION 4**
	4	**4,1**	**4,10,6**	**4,10,6,1**
EXPERT 1	5	5	6	6
EXPERT 2	5	6	6	6
EXPERT 3	4	6	6	6
EXPERT 4	5	7	7	7
EXPERT 5	4	7	7	6
MEAN	**4,6**	**6,2**	**6,4**	**6,2**
TOTAL	**4,4**	**5,9**	**6,4**	**6,4**

ADOPTION OF ELECTRIC VEHICLES: WHICH FACTORS ARE REALLY IMPORTANT?

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ABSTRACT

Electric vehicles stand out for their ability to reduce pollution. However, electric vehicle sales have not been brisk despite their positive effects. The objective of this study is twofold: first, to determine the variables that predict the purchase of an electric vehicle from the implementation of an algorithm based on computational intelligence; second, to contrast these results with two panels of experts in consumer behavior and the automobile sector. An empirical study was carried out with 404 potential consumers in Spain with regard to their beliefs, attitudes and purchase intention. The results show that range, incentives and reliability are the most reliable predictors of purchase intention. Likewise, the experts posit that the selection of these three variables would be sufficient to know the purchase intention of potential buyers of electric vehicles. In addition, it provides useful information for policy makers and private companies for decision making in the electric vehicle marketing process.

Keywords: electric vehicles adoption; computational intelligence; consumer behavior; expert interviews.

1. Introduction

The globally widespread use of fossil fuels causes a large number of environmental problems. The growing concern about environmental problems has led to the development of environmentally friendly products. Specifically, this research focuses on the transport sector. The automobile sector at the individual consumer level is one of the main contributors to issues such as global warming, pollution and oil dependence. In this context, electric vehicles (EVs) have the ability to reduce CO_2 emissions as electricity can be produced from renewable energy sources (Mersky et al., 2016). In this sense, EVs have become an alternative in the transport sector. However, despite their positive effects, sales have been low. Following She et al., (2017), the present study considers EV as a vehicle which uses energy extracted from the electrical grid for part or all of its propulsion. Therefore, EV also includes both battery electric vehicles and plug-in hybrid electric vehicles.

In recent years, demand for EV has grown strongly. However, they only represent a small part of the total of the new car market in many countries. According to the European Automobile Manufacturers Association, EV registrations increased by about 50% in 2018 over the previous year. However, in 2018, EV represented only 2% of new vehicles registered in the European Union (ACEA, 2019). Recent studies also indicate that less than 20% of respondents are willing to replace their internal combustion vehicle (ICV) with an EV (Wang et al., 2018). At present, the general intention to buy an EV is rather low (Carley, Krause, Lane, & Graham, 2013). As a result, new studies are needed to assess consumer behavior and find new market growth formulas.

In recent years, research has grown in the area of EV adoption and purchase intention (Rezvani et al., 2015) with numerous studies analyzing the main motivations and/or barriers to purchase. The objective of this work is twofold: firstly, to determine the variables that predict the purchase of an EV from the implementation of an algorithm based on computational intelligence, and secondly, to contrast these results with two groups of experts related to the automobile sector itself and also to consumer behavior and market research. Consequently, this article contributes to the field of research by bringing together the analytical experience in generating an algorithm, as well as the field work experience of the selected experts. In order to achieve these objectives, an empirical study was conducted with 404 potential consumers in Spain about their beliefs, attitudes and intention to purchase EV. The data collected were used to model consumer behaviour using a model based on computational intelligence to determine which variables determine the purchase intention of an EV from the literature review. This article makes a theoretical contribution by showing that range, government incentives and vehicle reliability are the most reliable predictors of purchase intention. It also provides useful information for policy-makers and private business decision-makers in the EV marketing process. It is worth noting that most studies are contextualized in other countries. In this sense, Spain lacks solid empirical research on the problem under study. Therefore, the present study presents an added value to the area of knowledge. In short, for this research it is important to provide a framework for the adoption of EV in order to help companies understand consumer behavior and, as a consequence, increase their market share.

The work is structured as follows. First, a review of the literature is conducted to identify the main variables. Second, the research design is discussed and the data collection process is shown along with the questionnaire and the data analysis. Third, results are assessed and the conclusions and implications are presented. Lastly, the limitations and avenues for future research are pointed out.

2. Literature review

The introduction of EVs in the market is an important innovation and they are involved in the dissemination process of innovations (Rogers, 2010). This process posits that the adoption of innovations tends to follow a time series model starting with a small number of innovators and early adopters who purchase the product relatively early, followed by most consumers and ending when lagging consumers decide to adopt the innovation. In Spain, EVs are relatively new and the population still has limited knowledge about the product (Higueras-Castillo et al., 2019). In general, new technologies underpin another set of added barriers as a result of comparing these innovations with market-dominant designs in criteria such as price and performance (Adner, 2002). Thus, early adopters are usually willing to pay a higher price or face below-average performance for the latest technology. Widespread adoption of an innovation usually requires a long period of time, even when it has obvious advantages (Rogers, 2010). The slow development of EV adoption may be related to the phenomenon of slow dissemination of environmentally friendly innovations. In this regard, despite the significant benefits, there are obstacles to widespread adoption.

The purpose of this research is to analyze consumers' intention to adopt. Intention is defined as an indication "of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior" (Ajzen, 1991). Specifically, it examines a combination of technological and contextual factors that affect consumers' adoption intentions. In this sense, numerous researchers have analyzed the drivers and barriers to EV adoption (Hjorthol, 2013; Rezvani et al., 2015). Most authors focus on technological factors and consumer characteristics that determine the purchase of an electric vehicle (Carley et al., 2013). Consumer perceptions of the intention to adopt EV have also been studied (Bunce, Harris & Burgess, 2014; She et al., 2017). These factors can be classified into three broad groups (Bjerkan, Nørbech & Nordtømme, 2016; Sierzchula et al., 2014):

1. Technological factors: driving range (Graham-Rowe et al., 2012; Jensen et al., 2013), charging time (Hidrue et al., 2011), battery characteristics (Lieven et al., 2011), noise (Skippong & Garwood, 2011), CO_2 emissions (Jensen et al., 2013; Krupa et al., 2014; Peters & Dütschke, 2014; Zubaryeva et al., 2012), functionality and reliability (Schmalfuβ et al., 2017) and image (Burgess, King, Harris & Lewis, 2013).
2. Context factors: government incentives (Higueras-Castillo et al., 2019; Zhang et al., 2011), fuel price and electricity price (Dijk, Orsato & Kemp, 2013; Zubaryeva et al., 2012) and charging infrastructures (Egbue & Long, 2012; Tran et al., 2012).
3. Consumer characteristics: socio-economic (Zhang et al., 2011), lifestyle (Axsen, TyreeHageman & Lentz, 2012; Lane & Potter, 2007), social norms (Caperello, Kurani & TyreeHageman, 2013; Moons & Pelsmacker, 2012) and environmental beliefs (Krupa et al., 2014; Schuitema et al., 2013).

Consumer characteristics are often less important than vehicle price and performance attributes (Lane & Potter, 2007). In addition, the target population is more concerned about technical than financial problems (Egbue & Long, 2012). The present study focuses on technological and contextual factors. Previous studies show that these variables influence the adoption of electric vehicles, for example, She et al. (2017) indicate that the main barriers are financial concerns (i.e., price) and technological factors such as safety, reliability, range, charging time, acceleration and the lack of charging infrastructure. Specifically for this research, the factors shown in Figure 1 have been selected.

INSERT FIGURE 1

2.1. Technological factors

First, consumers are sensitive to limited driving range (Lieven et al., 2011). In general, EVs already have ranges of up to approximately 400 km. The longest range is 660 km on the Tesla Model S. In contrast, an ICV can cover an average distance of 800 km with a petrol engine. Different authors have identified this difference as one of the main barriers to adoption (Lim et al., 2014). Even after the experience of having an EV for a period of time, most users were concerned about the driving range (Jensen et al., 2013). Generally, improving range through adequate charging infrastructure leads to greater adoption (Lim et al., 2014). On the other hand, Franke & Krems (2013) consider that range is a barrier to adoption, however, the experience of driving EV produces adaptation and that would reduce the practical limitations of low driving range. Therefore, this factor is a major concern for users and it negatively influences adoption (Jensen et al., 2014; She et al., 2017).

Second, charging time is another factor influencing EV adoption (Hidrue et al., 2011). The scientific literature considers charging time to be one of the most important variables affecting adoption. For most users, the charging process is complex due to long charging times (Graham-Rowe et al., 2012). While ICVs can be refueled in approximately four minutes, EVs require at least 30 minutes at a fast charging station and up to 8 hours to charge at a lower voltage outlet (Glerum, Stankovikj, Thémans & Bierlaire, 2013). According to Sellmair & Schelo, (2019), it is very important to reduce waiting times. However, recent studies indicate that users are willing to adapt to the charging process of an EV (Schmalfuβ et al., 2017). In conclusion, reducing charging time and increasing the range of EVs should significantly improve the intention to purchase EV (Junquera et al., 2016).

With regard to the performance of an EV, consumers in general are not satisfied (Graham-Rowe, Gardner, Abraham, Skippon, Dittmar, Hutchins, & Stannard, 2012). However, EVs have the potential to perform better than ICVs, so this advantage can compensate for more unfavorable factors such as limited range, long charging time and high price (Skippon, 2014). It is recognized that performance attributes have a greater effect on consumer acceptance than financial or environmental awareness factors (Zhang et al., 2013). On the other hand, other studies indicate that environmental benefits and incentives are more relevant than performance characteristics (Peters & Dütscke, 2014).

Two attributes that differ clearly from ICVs can be highlighted: fast acceleration and low engine noise. Burgess et al., (2013) reported that respondents were impressed by the acceleration and low noise of EVs. In this regard, EVs produce faster acceleration at low speeds and quietness compared to an ICV (Skippon, 2014). Also, Ozaki & Sevastyanova (2011) found that quietness affects the adoption of EV as it is considered an added value to the purchase increasing consumers' positive perception of EVs. In short, these factors favorably influence the acceptance of EVs (Skippon & Garwood, 2011). However, authors such as Mabit & Fosgerau (2011) pointed out that acceleration time is not significant.

On the other hand, safety and reliability are two of the main concerns of consumers (Fang, 2010; Zhang et al., 2013). According to the study conducted by Egbue & Long, (2012), 57% of respondents agreed or strongly agreed that EVs are a safe means of transport, while 26% indicated that they did not feel safe. Also, those who did not have previous experience with an EV perceived it to be more insecure compared to those who indicated they had some experience. In the study by She et al., (2017), safety and reliability scored highest. In this case, it is implied that respondents do not trust EVs and are concerned about the safety of using this technology. These results were mainly due to the fact that the battery has caught fire in some accidents. Also, in the work of Graham-Rowe et al., (2012), drivers lacked reliability, which raises safety issues. Similarly, reliability is highlighted as one of the main motivators for purchasing an EV (Egbue & Long, 2012; Higueras-Castillo et al., 2019). In addition, in the study by Ozaki & Sevastyanova, (2011), EV is perceived as a reliable technology by consumers.

2.2. Context factors

The high purchase price is one of the strongest barriers to the purchase of EV. Consumers are not willing to pay a large premium for an EV (Larson et al., 2014). Sierchula et al., (2014) demonstrated in approximately 30 countries that the price of EVs has a negative correlation with market share. Different authors point out that reducing the price could increase the willingness to buy an EV (Junquera et al., 2016) and its competitiveness (Feng & Figliozzi, 2013). Therefore, high cost becomes one of the main concerns of consumers (Egbe & Long, 2012), affecting the intention to purchase EVs (Fang, 2010). In conclusion, the high purchase price is a major disadvantage (Heyvaert, Coosemans, Mierlo, & Macharis, 2015).

On the other hand, EVs have advantages in terms of recharge price and maintenance costs, constituting one of the main motivations associated with the purchase (Ozaki & Sevastyanova, 2011). The work of Zhang et al. (2013) identifies financial benefits as a driver of EV acceptance. Taking into account fuel and energy prices, the cost of charging the batteries of EVs is less than the cost of refueling ICVs (Carley et al., 2013). While electricity can be approximately four times cheaper than replenishing an ICV, the purchase price of EVs is approximately three times higher (Feng & Figliozzi, 2013). Different studies indicate that the increase in the price of gasoline contributes significantly to the market share of EV (Beresteanu & Li 2011; Gallagher and Muehlegger, 2011). As the price of gasoline rises, more individuals consider EVs to be worthwhile investments (Egbue & Long, 2012; Graham-Rowe et al., 2012). Thus, in comparison, the low price of electricity increases the adoption of EV (Soltani-Sobh et al., 2017). It was found that there were significant savings in societal costs and total cost of ownership when compared to diesel vehicles (Bóren, 2019). On the other hand, electric motors are less complex propulsion systems than ICV, which means they are less costly to maintain (Graham-Rowe et al., 2012; Taefi et al., 2014). Therefore, the perceived benefit has a positive effect on purchase intention (He, Zhan & Hu, 2018; Kim et al., 2018). However, despite these savings, consumers may still refuse to buy the product. It is the so-called energy-efficiency paradox or energy-efficiency gap (Gallingham & Palmer, 2014). Different studies posit that respondents do not value this benefit very much or are not aware of this potential cost saving (Carley et al., 2013). In this sense, consumers are more influenced by the high purchase price and do not take into account the total cost of ownership of EVs (Sierchula et al., 2014). Moreover, many consumers consider that the high purchase price is not justified, even after taking into account possible savings (Graham-Rowe et al., 2012).

With this in mind, in recent years, governments have implemented different policy measures to increase interest in EV (Lieven, 2015; Sierzchula et al., 2014). Literature shows incentives implemented in the USA (Jin et al., 2014), Europe (Gass, Schmidt & Schmid 2014; Kley et al., 2012) and worldwide (Leurent & Windisch, 2011). In this regard, Sierzchula et al., (2014) analyzed the correlation between incentives and market shares of EV in 30 countries. The results showed that incentives are a predictor of adoption. Lévay et al., (2017) assessed the relationship between the total cost of ownership (TCO) of the EV and the impact of tax incentives on it relative to ICVs in eight European countries. The results show that in Norway the incentives lead to a lower TCO and in the Netherlands, France and the United Kingdom the TCO of the EVs is close to the TCO of the ICVs. However, in the other countries, the TCO is still higher than in ICV. In conclusion, the literature shows that incentives positively influence the acceptance of EV (Kim et al., 2018; Langbroek et al., 2016). Krupa et al., (2014) suggest that increasing consumer awareness of the existence of incentives could have a greater impact on perceived benefits. Also, as a consequence of low buyer motivation, Turcksin et al. (2013) confirm that increasing the adoption of alternative mobility vehicles requires a stable and rigorous incentive policy. In this way, incentives reduce the cost of purchasing an EV to a comparable ICV (Bjerkan et al., 2016). However, some authors show in their research a negligible

(Zhang et al., 2014) or weak (Harrysson, Ulmefors, & Kazlova, 2015) correlation between incentives and consumer willingness to buy EV. According to Wang et al., (2019) tax incentives are no longer the cause of large differences between countries.

According to Egnér & Trosvik (2018) local incentive measures such as investment in infrastructure also has a significant impact on the adoption rate. The charging infrastructure is essential, so its unavailability makes it an obstacle to its adoption (Tran et al., 2012). According to She et al., (2017), the lack of charging infrastructure is the greatest impediment to adoption. In their work, Jensen et al., (2013) showed that charging stations in public places are important for the purchase of EVs. While Krupa et al., (2014), pointed out that having facilities at home to charge the battery overnight is important for consumers, it is also important for the safety of the vehicle and the charging cable (Caperello & Kurani, 2012). Therefore, the number of charging stations is a predictor of EV adoption (Sierzchula et al., 2014) and access to them is a key determinant of adoption (Mersky et al., 2016). The key difference between electric and conventional vehicles is the charging infrastructure, among others (Gnann, Stephens, Lin, Plötz, Liu, & Brokate, 2018). According to Wang et al., (2019), charger density correlates positively with a country's EV market share.

3. Materials and methods

3.1. Data collection

Data collection was conducted through an online survey with a structured and pre-coded questionnaire developed from April to July 2018. Data were obtained through a non-probability sampling method defined by quotas according to the structure of the population. A research company specialized in sampling services was designated to select participants randomly. The sample consists of 404 potential consumers of EV. Respondents are Spaniards over 18 years old with a driving licence. Table 1 shows the classification characteristics of respondents.

In order to reduce the abandonment rate once the questionnaire was initiated, the following measures were implemented: 1) the purpose of the research was clearly explained and declared non-profit; 2) the researcher and the university were identified; 3) confidentiality and anonymity were guaranteed; 4) it was indicated that there were no valid or invalid answers, only the opinion of the respondents was interesting; 5) all questions were closed; 6) the visual design was clear and simple. Also, during the initial stage of this research, the robustness of the measurement scales used was tested. In addition, this study made sure that respondents understood and approached the survey correctly.

INSERT TABLE 1

3.2. Questionnaire

This research adopted the use of a seven-point Likert scale (except for demographic variables). The scale ranges from 1 (strongly disagree) to 7 (strongly agree), according to the respondent's level of agreement with each ítem. The sociodemographic information part was completed by respondents choosing the corresponding options.

To be more precise, the range, charging, acceleration, noise, safety and reliability scale was adapted from the work of Schmalfuß et al. (2017). Price was assessed on the basis of two scales of work by He and Zhan (2018) and Petrick (2002). Financial benefit and incentives was adjusted from Wang et al., (2017). Infrastructure was adapted by He and Zhan (2018) and Jansson (2011). Lastly, intention of adoption was adapted from the scales of Moons & Pelsmacker (2012) and Barbarossa Pelsmacker & Moons, (2017). Appendix A shows the measurement scales used in this research.

3.3. Performing variable selection

The selection of variables is a complex issue but one of great importance in an uncountable number of problems across all disciplines. The basis of this type of technique is the arrangement of a measure of relevance/correlation between variables. In the case of the present study, such a measure will be mutual information, a non-linear correlation measure from Shannon's Information Theory (Cover 1991). This measure estimates the amount of information that a group of variables has about the target variable (or variables). Its definition in the continuous case is:

$$I(X,Y) = \int \frac{\mu_{X.Y}(x,y) log\left(\mu_{X.Y}(x,y)\right)}{\mu_X(x)\mu_Y(y)} dxdy$$

where $\mu_{X.Y}(x,y)$ is the joint probability density function (PDF) of X and Y, and $\mu_X(x)$ $\mu_X(x)$ is the marginal density function of the set of variables X. Its advantage in comparison with other correlation criteria is that it is able to identify non-linear relations among the variables involved. Several Mutual Information estimators can be found in the specific literature, however, the k-nearest neighbors one (Kraskov et al. 2004), was found to have a more robust behavior with respect to other alternatives and therefore it is the estimator approached in this work.

The objective of variable selection algorithms is to choose the smallest possible set of factors that contain all the necessary information on the target variable for decision-making, avoiding factors that are not influential in any case, or, and not of minor importance, that are redundant with respect to others already considered. The advantages of this type of factor selection are multiple: faster, and sometimes even more effective, subsequent computational modeling, improved interpretability, easier communication between experts and more economic measurement, etc.

In this work, an algorithm adapted from Koller and Sahami (1996) was used and applied to diverse problems where the most irrelevant and redundant factors of a problem are identified iteratively and in order, leaving in last place the really significant factors of the same one (Herrera, Pomares, Rojas, Verleysen, & Guilén, 2006; LaFuente et al., 2014). Thus, at the end an inverted ranking of factors is obtained where in first place the most important factor is left, then the second most important factor taking into account the first one, and so on.

This algorithm is based on the *Markov blanket* concept. Given a set of input variables X and an output variable Y, a set of variables M_i in X is said to be a *Markov blanket* for a variable x_i in X with respect to Y, if $I(\{M_i \cup x_i\},Y = I(M_i,Y)$ $I(\{M_i \cup x_i\},Y) == I(x_i,Y)$, that is, if M_i has itself all the information that x_i has about Y. A Markov blanket is thus a group of variables subsuming the information content of a certain variable over the output Y variable. The algorithm thus operates in a backwards way, starting from the complete set of variables, and iteratively discarding those which are detected to have a Markov Blanket in the remaining set X_G of variables.

The algorithm states the following steps:

1. Calculate the MI between every pair of input variables I (x_i, x_j)
2. Starting from the complete set of input variables X_G = X, iterate:
    a) For each variable xi, let the candidate Markov blanket Mi be the set of p variables in X_G for which I (x_i, x_j) is highest.
    b) Compute for each xi
    $$Loss_i = I(\{M_i \cup x_i\},Y) - I(M_i,Y)$$
    $$Loss_i = I(\{M_i \cup x_i\},Y) - I(M_i,Y)$$
    c) Choose the x_i for which $Loss_i$ is lowest and eliminate x_i from X_G.
3. Continue with step 2 until no variables remain.

The p parameter of the algorithm (in step 2.a of the algorithm) will take the value p = 1, as recommended in previous works (Koller and Sahami, 1996; Herrera et al., 2006).

Once the relevance ranking has been established using the above algorithm, it is necessary to identify the number of factors necessary to reach the target performance, which is usually done to obtain all the information provided by all the factors involved in the problem. A computational intelligence method can be used to estimate the performance of each combination of factors. Due to the fact that the evaluation of the final user of purchase of EV is the average of the values of the respondents' responses, being this between 1 and 7, the Least Squares Support Vector Machines (LSSVM) methodology was considered as a reference method for regression problems of medium and small size (Suykens et al. 2002) to estimate the performance of the factors in the purchase preference of EV. Before applying the method of variable selection and data modeling, preprocessing was performed. First, there were questions whose high value implied a positive perception of the EV while other questions represented the opposite. In this sense, the results of the variables with the negative score were inverted so that, for each question, all the high values corresponded to a positive attitude toward the EV. In addition, since there were redundant questions that focused on the same aspect, it was decided to unify by averaging the groups of redundant questions. Thanks to this step, this study went from 42 initial variables (one per question) to the 10 factors considered. Similarly, in order to be able to deal with a single output, the three questions related to purchase intention were also grouped together, moving from three possible values to one. Thus, given the data set of 404 surveys, the 10 factors considered and the purchase estimate, the characteristics selection algorithm was applied, obtaining the order of characteristics given in figure 2. The application of different LSSVM models to the first factor, first two factors, first three factors, etc., led to the performance observed in Figure 3. These results were further corroborated under different subdivisions of training and random tests of the global data set.

INSERT FIGURE 2 AND FIGURE 3

3.4. Research results

In order to validate the results achieved with the proposed method, a group of experts grouped into two different categories was contacted: researchers related to consumer behavior and market research with an international research curriculum and professionals from the automobile sector with experience in sales of electric vehicles. All the selected experts have a minimum of ten years of experience in each of their sectors.

The validation process was established in four stages throughout the first semester of 2019 and included in-depth interviews, evaluation of methods, evaluation of results and feedback. Firstly, an in-depth interview was held with the experts to explain in detail the type of experiment carried out and to select the set of variables they considered relevant to know in order to determine the level of intended use. Secondly, they were provided with the sets of variables that had been predefined with the proposed method so that they could value them according to a Likert scale (1-7). Lastly, once the results had been grouped and the statistical conclusions of each of the results of the proposed methods had been established, the ranking of each of them was communicated to them, stating the level of agreement with the result achieved by means of a personal interview to justify their responses and analyze the group results. Figure 2 shows the result of the selection of the analyzed variables. The results of the assessments carried out by each of the groups of experts are shown in Table 2.

INSERT TABLE 2

In general terms, as seen in table 2, the most valued options are 3 and 4, which include the variables range, incentives and reliability, in the first case, and, in the second, acceleration together with the previous options (average valuation = 6.4). In this sense, with the same average valuation, option 3 uses one less selection variable, so in terms of performance this option would be better than option 4.

The best option valued by the group of researchers on consumer behavior is option 4, which includes a greater number of selection variables to determine the general intention to buy EV (6.6). Although it is true that option 3 obtains a high average (6.4) by sacrificing a variable in the choice of variables that facilitate the decision making process to buy an EV, it is also true that option 3 obtains a high average (6.4) by sacrificing a variable in the choice of variables that facilitate the decision making process to buy an EV. On the other hand, in the case of professionals related to the automotive sector, they value option 3 (6.4) to a greater extent instead of option 4 (6.2).

After a joint analysis of the results with the group of experts in a second interview, the main reasons for the score for each of the options proposed were as follows:

With respect to option 1: It only includes one variable such as driving range (4.4) which, although relevant, is not the only one that determines the purchase intention of an EV, as it ignores the rest of the variables. The researchers argue that this option is not valid because it uses a particularly restricted criterion.

Regarding option 2: This option includes range and incentives, and is valued more positively than the previous option (5.9). This option is supported by both groups of experts, making a technological element compatible with another contextual element that arouses high interest among potential buyers. On this occasion, the valuation of professionals in the automobile sector surpasses the valuation of professionals in the study of consumer behavior and market research (6.2 versus 5.6).

Regarding option 3: This option includes range, incentives and reliability and is assessed identically by both groups of experts. The experts understand that this option achieves a balance in the valuations of the selected variables (6.4 in both groups of experts).

Finally, with respect to option 4: This last option includes range, incentives, reliability and acceleration. In this case, professionals studying consumer behavior and market research value the inclusion of the last variable (acceleration) more positively than professionals in the automobile sector (6.6 versus 6.2).

4. Conclusions, managerial implications and avenues for future research

4.1. Discussion of results and managerial implications

For this research it is important to provide a theoretical frame of reference for the adoption of EV that helps companies understand consumer behavior and, as a consequence, increase their market share. The purpose of this study is twofold. Firstly, to analyze intention to adopt EV. Specifically, to determine through a set of variables the factors predicting behavior more reliably. This is done by implementing an algorithm based on computational intelligence. Secondly, a set of experts related to the automobile sector and specialists in consumer behavior and market research contrast these results under their own experience and opinion.

The literature shows numerous elements that must be considered to understand a consumer's purchase intention at the time of purchasing an EV. From an exhaustive review, the most representative factors were selected. They can be classified into technological factors: driving range, charging time, noise, acceleration, safety and reliability; and contextual factors: price, perceived benefit, incentives and infrastructure availability.

The objective of variable selection algorithms is to choose the smallest possible set of factors that contain all the necessary information on the target variable for decision-making, avoiding factors that are not influential in any case, or, and not of minor importance, that are redundant with respect to others already considered. The results of this research indicate that among all the elements studied, the problem is reduced to three factors: range, incentives and reliability. These three variables make it possible to model all the responses given by consumers with the greatest precision. The rest of the variables do not provide significant information that would allow this approximation to be improved. In other words, the yield obtained by these factors is similar to the use of a greater number of factors.

On the other hand, in order to validate the results obtained, a series of interviews were carried out with expert researchers related to consumer behavior and market research with an international research curriculum and professionals from the automobile sector with experience in sales of EV. From the statistical conclusions, it is observed that a balance is reached with the inclusion of the first three variables, which determines that the proposed experts understand that the selection of these three variables would be sufficient to know the purchase intention of potential buyers of EVs. These experimental results corroborate the theoretical results of the proposed algorithm.

It is interesting to see how the automobile industry expert group valued the set of variables selected by the variable selection method the most. This same selection also gets a very good score by marketing experts who prefer to include acceleration. It is understandable that experts take into account this variable because it is very easy to translate into an ad, slogan and advertising campaign in general. However, after conducting the objective analysis of the data plus the opinion of automotive experts, there is no doubt with regard to the three elements that should guide the industry in improving purchase intent.

4.2. Limitations, recommendations and avenues for future research

This research has several limitations in interpreting the results obtained which offer different lines for future research. In the first place, to assess the purchasing behavior with regard to EVs, intention to adopt is examined. In this sense, intention to adopt is considered a proxy for actual behavior and can therefore predict it (Hung et al., 2013). However, this does not exempt that it may not be fully representative. At the same time, the sample is composed of potential consumers, most of whom have had no previous experience with EVs. Therefore, a future study should be carried out to investigate the actual behavior of consumers, as well as to analyze the beliefs and attitudes of current consumers. Secondly, the sample is obtained in Spain. Considering the cultural differences between countries and the level of development of the EV market, there may be problems in generalizing the results. In this sense it would be important to verify the results obtained by the present study with a sample of other countries. On the other hand, data collection was conducted through an online survey platform. This method may incur a sample bias as consumers who do not use the Internet are not included in the sample. Therefore, future studies should consider the inclusion of offline consumers. Finally, this research examines all types of EV. The results may be different depending on the type of vehicle, so future studies may distinguish between them and then compare the results. In addition, future research is invited to include a number of other personal factors, including environmental beliefs highly valued in other works (Krupa et al., 2014) or socioeconomic beliefs (Zhang et al., 2011) and lifestyle factors (Axsen et al., 2012).

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References

ACEA (2019). Economic and Market Report. EU Automotive Industry. Full-year 2018. *European Automobile Manufacturesrs Association*. Available in https://www.acea.be/uploads/statistic_documents/Economic_and_Market_Report_full-year_2018.pdf Accessed 2 July 2019.

Adner, R. (2002). When are technologies disruptive? A demand-based view of the emergence of competition. *Strategic Management Journal*, *23*(8), 667-688. https://doi.org/10.1002/smj.246

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-t

Axsen, J., TyreeHageman, J., & Lentz, A. (2012). Lifestyle practices and pro-environmental technology. *Ecological Economics*, *82*, 64-74. https://doi.org/10.1016/j.ecolecon.2012.07.013

Bakker, S., & Trip, J. J. (2013). Policy options to support the adoption of electric vehicles in the urban environment. *Transportation Research Part D: Transport and Environment*, *25*, 18-23. https://doi.org/10.1016/j.trd.2013.07.005

Barbarossa, C., De Pelsmacker, P., & Moons, I. (2017). Personal values, green self-identity and electric car adoption. *Ecological Economics*, *140*, 190-200. https://doi.org/10.1016/j.ecolecon.2017.05.015

Beresteanu, A., & Li, S. (2011). Gasoline prices, government support, and the demand for hybrid vehicles in the United States. *International Economic Review*, *52*(1), 161-182. https://doi.org/10.1111/j.1468-2354.2010.00623.x

Bjerkan, K. Y., Nørbech, T. E., & Nordtømme, M. E. (2016). Incentives for promoting battery electric vehicle (BEV) adoption in Norway. *Transportation Research Part D: Transport and Environment*, *43*, 169-180. https://doi.org/10.1016/j.trd.2015.12.002

Borén, S. (2019). Electric buses' sustainability effects, noise, energy use, and costs. *International Journal of Sustainable Transportation*, 1-16. https://doi.org/10.1080/15568318.2019.1666324

Bunce, L., Harris, M., & Burgess, M. (2014). Charge up then charge out? Drivers' perceptions and experiences of electric vehicles in the UK. *Transportation Research Part A: Policy and Practice*, *59*, 278-287. https://doi.org/10.1016/j.tra.2013.12.001

Burgess, M., King, N., Harris, M., & Lewis, E. (2013). Electric vehicle drivers' reported interactions with the public: Driving stereotype change?. *Transportation research part F: traffic psychology and behaviour*, *17*, 33-44. https://doi.org/10.1016/j.trf.2012.09.003

Caperello, N. D., & Kurani, K. S. (2012). Households' stories of their encounters with a plug-in hybrid electric vehicle. *Environment and behavior*, *44*(4), 493-508. https://doi.org/10.1177/0013916511402057

Caperello, N., Kurani, K. S., & TyreeHageman, J. (2013). Do You Mind if I Plug-in My Car? How etiquette shapes PEV drivers' vehicle charging behavior. *Transportation Research Part A: Policy and Practice*, *54*, 155-163. https://doi.org/10.1016/j.tra.2013.07.016

Carley, S., Krause, R. M., Lane, B. W., & Graham, J. D. (2013). Intent to purchase a plug-in electric vehicle: A survey of early impressions in large US cites. *Transportation Research Part D: Transport and Environment*, *18*, 39-45. https://doi.org/10.1016/j.trd.2012.09.007

Cover, T. M., & Thomas, J. A. (1991). Elements of information theory. Wiley Series in Telecommunications. https://doi.org/10.1002/0471200611

Dijk, M., Orsato, R. J., & Kemp, R. (2013). The emergence of an electric mobility trajectory. *Energy Policy*, *52*, 135-145. https://doi.org/10.1016/j.enpol.2012.04.024

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy policy*, *48*, 717-729. https://doi.org/10.1016/j.enpol.2012.06.009

Egnér, F., & Trosvik, L. (2018). Electric vehicle adoption in Sweden and the impact of local policy instruments. *Energy policy*, *121*, 584-596. https://doi.org/10.1016/j.enpol.2018.06.040

Fang, X. G. H. X. (2010). Impact Factors of Purchase Decision of New Energy Automobile [J]. *China Population, Resources and Environment*, *11*.

Feng, W., & Figliozzi, M. (2013). An economic and technological analysis of the key factors affecting the competitiveness of electric commercial vehicles: A case study from the USA market. *Transportation Research Part C: Emerging Technologies*, *26*, 135-145. https://doi.org/10.1016/j.trc.2012.06.007

Franke, T., & Krems, J. F. (2013). Interacting with limited mobility resources: Psychological range levels in electric vehicle use. *Transportation Research Part A: Policy and Practice*, *48*, 109-122. https://doi.org/10.1016/j.tra.2012.10.010

Gallagher, K. S., & Muehlegger, E. (2011). Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology. *Journal of Environmental Economics and management*, *61*(1), 1-15. https://doi.org/10.1016/j.jeem.2010.05.004

Gass, V., Schmidt, J., & Schmid, E. (2014). Analysis of alternative policy instruments to promote electric vehicles in Austria. *Renewable Energy*, *61*, 96-101. https://doi.org/10.1016/j.renene.2012.08.012

Gillingham, K., & Palmer, K. (2014). Bridging the energy efficiency gap: Policy insights from economic theory and empirical evidence. *Review of Environmental Economics and Policy*, *8*(1), 18-38. https://doi.org/10.1093/reep/ret021

Gnann, T., Stephens, T. S., Lin, Z., Plötz, P., Liu, C., & Brokate, J. (2018). What drives the market for plug-in electric vehicles?-A review of international PEV market diffusion models. *Renewable and Sustainable Energy Reviews*, *93*, 158-164. https://doi.org/10.1016/j.rser.2018.03.055

Glerum, A., Stankovikj, L., Thémans, M., & Bierlaire, M. (2013). Forecasting the demand for electric vehicles: accounting for attitudes and perceptions. *Transportation Science*, *48*(4), 483-499. https://doi.org/10.1287/trsc.2013.0487

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., & Stannard, J. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice*, *46*(1), 140-153. https://doi.org/10.1016/j.tra.2011.09.008

Harrysson, S., Ulmefors, M., & Kazlova, A. (2015). Overview and analysis of electric vehicle incentives applied across eight selected country markets. H. Ny, ed., Karlskrona. http://www.diva-portal.org/smash/get/diva2:882227/FULLTEXT01.pdf (Accessed 3 July 2019).

He, X., & Zhan, W. (2018). How to activate moral norm to adopt electric vehicles in China? An empirical study based on extended norm activation theory. Journal of Cleaner Production, 172, 3546-3556. https://doi.org/10.1016/j.jclepro.2017.05.088

He, X., Zhan, W., & Hu, Y. (2018). Consumer purchase intention of electric vehicles in China: The roles of perception and personality. *Journal of cleaner production*, *204*, 1060-1069. https://doi.org/10.1016/j.jclepro.2018.08.260

Herrera, L. J., Pomares, H., Rojas, I., Verleysen, M., & Guilén, A. (2006). Effective input variable selection for function approximation. In *International Conference on Artificial Neural Networks*, 41-50. Springer, Berlin, Heidelberg. https://doi.org/10.1007/11840817_5

Heyvaert, S., Coosemans, T., Mierlo, J. V., & Macharis, C. (2015). Electric vehicle attitudes and purchase intention: a Flemish case study. *International Journal of Electric and Hybrid Vehicles*, *7*(1), 83-100. https://doi.org/10.1504/ijehv.2015.068946

Hidrue, M. K., Parsons, G. R., Kempton, W., & Gardner, M. P. (2011). Willingness to pay for electric vehicles and their attributes. *Resource and energy economics*, *33*(3), 686-705. https://doi.org/10.1016/j.reseneeco.2011.02.002

Higueras-Castillo, E., Liébana-Cabanillas, F. J., Muñoz-Leiva, F., & García-Maroto, I. (2019). Evaluating consumer attitudes toward electromobility and the moderating effect of perceived consumer effectiveness. *Journal of Retailing and*

Consumer Services, *51*, 387-398. https://doi.org/10.1016/j.jretconser.2019.07.006

Hjorthol, R. (2013). Attitudes, ownership and use of Electric Vehicles–a review of literature. *National Academy of Sciences*.

Hung, S. Y., Ku, C. Y., & Chang, C. M. (2003). Critical factors of WAP services adoption: an empirical study. *Electronic Commerce Research and Applications*, *2*(1), 42-60. https://doi.org/10.1016/s1567-4223(03)00008-5

Jansson, J. (2011). Consumer eco-innovation adoption: assessing attitudinal factors and perceived product characteristics. Business Strategy and the Environment, 20(3), 192-210. https://doi.org/10.1002/bse.690

Jensen, A. F., Cherchi, E., & de Dios Ortúzar, J. (2014). A long panel survey to elicit variation in preferences and attitudes in the choice of electric vehicles. *Transportation*, *41*(5), 973-993. https://doi.org/10.1007/s11116-014-9517-6

Jensen, A. F., Cherchi, E., & Mabit, S. L. (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle. *Transportation Research Part D: Transport and Environment*, *25*, 24-32. https://doi.org/10.1016/j.trd.2013.07.006

Jin, L., Searle, S., & Lutsey, N. (2014). Evaluation of state-level US electric vehicle incentives. *The International Council on Clean Transportation*.

Junquera, B., Moreno, B., & Álvarez, R. (2016). Analyzing consumer attitudes towards electric vehicle purchasing intentions in Spain: Technological limitations and vehicle confidence. *Technological Forecasting and Social Change*, *109*, 6-14. https://doi.org/10.1016/j.techfore.2016.05.006

Kim, M. K., Oh, J., Park, J. H., & Joo, C. (2018). Perceived value and adoption intention for electric vehicles in Korea: Moderating effects of environmental traits and government supports. *Energy*, *159*, 799-809. https://doi.org/10.1016/j.energy.2018.06.064

Kley, F., Wietschel, M., & Dallinger, D. (2012). Evaluation of European electric vehicle support schemes. *Paving the Road to Sustainable Transport. New York: Routledge*, 75-95.

Koller, D., & Sahami, M. (1996). Toward optimal feature selection. Stanford InfoLab. Proceed- ings of 13th International Conference on Machine Learning, Bari, Italy, 3–6 July 1996, 284–292.

Kraskov, A., Stögbauer, H., & Grassberger, P. (2004). Estimating mutual information. *Physical review E*, *69*(6), 066138. https://doi.org/10.1103/physreve.69.066138

Krupa, J. S., Rizzo, D. M., Eppstein, M. J., Lanute, D. B., Gaalema, D. E., Lakkaraju, K., & Warrender, C. E. (2014). Analysis of a consumer survey on plug-in hybrid electric vehicles. *Transportation Research Part A: Policy and Practice*, *64*, 14-31. https://doi.org/10.1016/j.tra.2014.02.019

Lafuente, V., Herrera, L. J., Pérez, M. D. M., Val, J., & Negueruela, I. (2015). Firmness prediction in Prunus persica 'Calrico'peaches by visible/short-wave near infrared spectroscopy and acoustic measurements using optimised linear and non-linear chemometric models. *Journal of the Science of Food and Agriculture*, *95*(10), 2033-2040. https://doi.org/10.1002/jsfa.6916

Lane, B., & Potter, S. (2007). The adoption of cleaner vehicles in the UK: exploring the consumer attitude–action gap. *Journal of cleaner production*, *15*(11-12), 1085-1092. https://doi.org/10.1016/j.jclepro.2006.05.026

Langbroek, J. H., Franklin, J. P., & Susilo, Y. O. (2016). The effect of policy incentives on electric vehicle adoption. *Energy Policy*, *94*, 94-103. https://doi.org/10.1016/j.enpol.2016.03.050

Larson, P. D., Viáfara, J., Parsons, R. V., & Elias, A. (2014). Consumer attitudes about electric cars: Pricing analysis and policy implications. *Transportation Research Part A: Policy and Practice*, *69*, 299-314. https://doi.org/10.1016/j.tra.2014.09.002

Leurent, F., & Windisch, E. (2011). Triggering the development of electric mobility: a review of public policies. *European Transport Research Review*, *3*(4), 221-235. https://doi.org/10.1007/s12544-011-0064-3

Lévay, P. Z., Drossinos, Y., & Thiel, C. (2017). The effect of fiscal incentives on market penetration of electric vehicles: A pairwise comparison of total cost of ownership. *Energy Policy*, *105*, 524-533. https://doi.org/10.1016/j.enpol.2017.02.054

Lieven, T. (2015). Policy measures to promote electric mobility–A global perspective. *Transportation Research Part A: Policy and Practice*, *82*, 78-93. https://doi.org/10.1016/j.tra.2015.09.008

Lim, M. K., Mak, H. Y., & Rong, Y. (2014). Toward mass adoption of electric vehicles: impact of the range and resale anxieties. *Manufacturing & Service Operations Management*, *17*(1), 101-119. https://doi.org/10.1287/msom.2014.0504

Mabit, S. L., & Fosgerau, M. (2011). Demand for alternative-fuel vehicles when registration taxes are high. *Transportation Research Part D: Transport and Environment*, *16*(3), 225-231. https://doi.org/10.1016/j.trd.2010.11.001

Mersky, A. C., Sprei, F., Samaras, C., & Qian, Z. S. (2016). Effectiveness of incentives on electric vehicle adoption in Norway. *Transportation Research Part D: Transport and Environment*, *46*, 56-68. https://doi.org/10.1016/j.trd.2016.03.011

Moons, I., & De Pelsmacker, P. (2012). Emotions as determinants of electric car usage intention. *Journal of Marketing Management*, *28*(3-4), 195-237. https://doi.org/10.1080/0267257x.2012.659007

Ozaki, R., & Sevastyanova, K. (2011). Going hybrid: An analysis of consumer purchase motivations. *Energy Policy*, *39*(5), 2217-2227. https://doi.org/10.1016/j.enpol.2010.04.024

Peters, A., & Dütschke, E. (2014). How do consumers perceive electric vehicles? A comparison of German consumer groups. *Journal of Environmental Policy & Planning*, *16*(3), 359-377. https://doi.org/10.1080/1523908x.2013.879037

Petrick, J. F. (2002). Development of a multi-dimensional scale for measuring the perceived value of a service. *Journal of leisure research*, 34(2), 119-134. https://doi.org/10.1080/00222216.2002.11949965

Rezvani, Z., Jansson, J., & Bodin, J. (2015). Advances in consumer electric vehicle adoption research: A review and research agenda. *Transportation research part D: transport and environment*, *34*, 122-136. https://doi.org/10.1016/j.trd.2014.10.010

Rogers, E. M. (2010). Diffusion of innovations. Simon and Schuster.

Schmalfuß, F., Mühl, K., & Krems, J. F. (2017). Direct experience with battery electric vehicles (BEVs) matters when evaluating vehicle attributes, attitude and purchase intention. *Transportation research part F: traffic psychology and behaviour*, *46*, 47-69. https://doi.org/10.1016/j.trf.2017.01.004

Schuitema, G., Anable, J., Skippon, S., & Kinnear, N. (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A: Policy and Practice*, *48*, 39-49. https://doi.org/10.1016/j.tra.2012.10.004

Sellmair, R., & Schelo, T. (2019). Analysis of the effect of charging infrastructure design on electric taxi driving profiles: A case study approach on the example of Singapore. *International Journal of Sustainable Transportation*, *13*(7), 479-496. https://doi.org/10.1080/15568318.2018.1485792

She, Z. Y., Sun, Q., Ma, J. J., & Xie, B. C. (2017). What are the barriers to widespread adoption of battery electric vehicles? A survey of public perception in Tianjin, China. *Transport Policy*, *56*, 29-40. https://doi.org/10.1016/j.tranpol.2017.03.001

Sierzchula, W., Bakker, S., Maat, K., & Van Wee, B. (2014). The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy*, *68*, 183-194. https://doi.org/10.1016/j.enpol.2014.01.043

Skippon, S. M. (2014). How consumer drivers construe vehicle performance: Implications for electric vehicles. *Transportation research part F: traffic psychology and behaviour*, *23*, 15-31. https://doi.org/10.1016/j.trf.2013.12.008

Skippon, S., & Garwood, M. (2011). Responses to battery electric vehicles: UK consumer attitudes and attributions of symbolic meaning following direct experience to reduce psychological distance. *Transportation Research Part D: Transport and Environment*, *16*(7), 525-531. https://doi.org/10.1016/j.trd.2011.05.005

Soltani-Sobh, A., Heaslip, K., Stevanovic, A., Bosworth, R., & Radivojevic, D. (2017). Analysis of the Electric Vehicles Adoption over the United States. *Transportation research procedia*, *22*, 203-212. https://doi.org/10.1016/j.trpro.2017.03.027

Suykens, J. A. K., Van Gestel, T., De Brabanter, J., De Moor, B., & Vandewalle, J. (2002). Least squares support vector machines. https://doi.org/10.1142/5089

Taefi, T. T., Kreutzfeldt, J., Held, T., Konings, R., Kotter, R., Lilley, S., ... & Borgqvist, M. (2016). Comparative Analysis of European Examples of Freight Electric Vehicles Schemes—A Systematic Case Study Approach with Examples from Denmark, Germany, the Netherlands, Sweden and the UK. In *Dynamics in Logistics*, 495-504. Springer, Cham. https://doi.org/10.1007/978-3-319-23512-7_48

Tran, M., Banister, D., Bishop, J. D., & McCulloch, M. D. (2012). Realizing the electric-vehicle revolution. *Nature climate change*, *2*(5), 328. https://doi.org/10.1038/nclimate1429

Turcksin, L., Mairesse, O., & Macharis, C. (2013). Private household demand for vehicles on alternative fuels and drive trains: a review. *European Transport Research Review*, *5*(3), 149-164. https://doi.org/10.1007/s12544-013-0095-z

Wang, N., Tang, L., & Pan, H. (2018). Analysis of public acceptance of electric vehicles: An empirical study in Shanghai. *Technological Forecasting and Social Change*, *126*, 284-291. https://doi.org/10.1016/j.techfore.2017.09.011

Wang, N., Tang, L., & Pan, H. (2019). A global comparison and assessment of incentive policy on electric vehicle promotion. *Sustainable Cities and Society*, *44*, 597-603. https://doi.org/10.1016/j.scs.2018.10.024

Wang, Z., Zhao, C., Yin, J., & Zhang, B. (2017). Purchasing intentions of Chinese citizens on new energy vehicles: How should one respond to current preferential policy?. *Journal of Cleaner Production*, *161*, 1000-1010. https://doi.org/10.1016/j.jclepro.2017.05.154

Zhang, X., Wang, K., Hao, Y., Fan, J. L., & Wei, Y. M. (2013). The impact of government policy on preference for NEVs: The evidence from China. *Energy Policy*, *61*, 382-393. https://doi.org/10.1016/j.enpol.2013.06.114

Zhang, Y., Yu, Y., & Zou, B. (2011). Analyzing public awareness and acceptance of alternative fuel vehicles in China: The case of EV. *Energy Policy*, *39*(11), 7015-7024. https://doi.org/10.1016/j.enpol.2011.07.055

Zubaryeva, A., Thiel, C., Barbone, E., & Mercier, A. (2012). Assessing factors for the identification of potential lead markets for electrified vehicles in Europe: expert opinion elicitation. *Technological Forecasting and Social Change*, *79*(9), 1622-1637. https://doi.org/10.1016/j.techfore.2012.06.004

Appendix A: Questionnaire

Adequate range and charging
The driving range of an E&HV is satisfying. The driving range of an E&HV is sufficient for my mobility needs in everyday life.
I do not mind that it takes longer to charge battery cells than to refuel. I could integrate the charging of the batteries in my everyday life without any problems.
Enjoyable acceleration
I would perceive the fast acceleration of EVs as pleasant. The immediate acceleration increases the driving comfort of Evs. I would like the racy acceleration of the EVs.
Enjoyable low noise emission
The lack of engine noise of EVs increases the driving pleasure. I would like the low soundscape of EVs. I would not need to change my driving style due to the noiselessness of the EVs. I believe that the lack of noise from the EV is not dangerous for road traffic. The lack of engine noise would not make driving more difficult.
Satisfying safety and reliability
I would be as safe in an EV as in a comparable conventional compact car. The safety in EVs is a given. An EV will take me safely to my destination.
I rely on the new technology of EVs. EVs are reliable. I can depend on an EV to reliably get me where I need to go.
Price
E&HVs are expensive. E&HVs are costly. The price of E&HVs is higher than that of corresponding gasoline cars. The price of EVs is higher than I expected.
Perceived benefit
The cost of charging the battery is very low. The maintenance costs are lower in EVs.
Incentives
It is easier to receive subsidies for the purchase of EVs than for the rest of vehicles. The purchase of an E&HV is more cost-effective when monetary incentives are in place.

It is easier to receive subsidies for the purchase of EVs than for the rest of vehicles. I am aware of the subsidies available for the purchase of EVs.
Infrastructure
It is hard to find a station where an EV can be charged. It is hard to find an auto repair shop that services EVs.
Intention to adopt
Next time I buy a car, I will consider buying an E&HV. I expect to drive an E&HV car in the near future. I have the intention to drive an E&HV in the near future.