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Price or performance? A probabilistic choice analysis of the intention to buy electric vehicles in European countries

This is a pre print version of the following article:

Original Citation:

Availability:

This version is available http://hdl.handle.net/2318/1663491 since 2018-04-04T10:54:45Z

Published version:

DOI:10.1016/j.enpol.2018.03.034

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06 September 2026

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Abstract

Traditional choice models perform poorly in understanding the determinants of the adoption of new products. First, data on pioneers and early adopters are biased towards specific performance characteristics of the product and the socio-demographic characteristics of the consumers. Second, surveys on the intention to buy underperform in detecting movements of those who do not intend to buy, who are the majority in the case of new products. Probabilistic choice models try to overcome this issue. By using survey data on electric vehicles, we theoretically contribute to this stream of literature and empirically estimate the impact of specific performance improvements and price reduction on the probability of consumers switching from non-intention to buy to intention to buy. Results show that price reduction is the most important triggering factor for the diffusion of electric vehicles, as it determines more than other factors the transition of consumers from the non-intention to the intention to buy an electric vehicle. The improvement in the driving range constitutes the second most important factor for low initial values of the stated intention to buy, while the possibility of recharging at home matters significantly more for consumers with high initial values of the stated intention to buy.

Keywords: electric vehicles, probabilistic choice models, intention to buy, European countries

1. Introduction

The quest for the worldwide market of electric vehicles has just begun. At the moment, Toyota, Tesla, and Volkswagen seem to have the greatest chance of success despite the tangible differences of their concepts of the future electric vehicle. It is hard to predict whether the killer improvement, characterising the dominant design of next generation vehicles, will be the price reduction, as happened a century ago for the Ford-T, or the development of key technical attributes such as the driving range (battery autonomy), the speed of recharge, or the horsepower. As for other innovative products and services, an elected tool to estimate the potential market for this innovation consists of the analysis of the purchase intentions of consumers. Indeed, psychological approaches combined with important contributions from the marketing literature can help identify consumers' attitudes towards innovations and the determinants of purchase intentions, which are often used to predict the sales of existing products over time, as they are assumed to be good indicators of consumers' purchasing behaviour (Sun and Morwitz, 2010; Arts et al., 2011). The analysis of consumers' purchasing intentions is an important issue also for policy makers, who might decide to implement specific interventions to stimulate the diffusion of new (sustainable) products and services. However, a well-known stylized fact in marketing research is that choice models underperform in detecting movement among consumers who are not yet convinced to buy. Without data on actual purchases, surveys asking for a binary intention to buy do not predict future actual purchases very well. On the contrary, stated probabilities to purchase are more reliable. We contribute to the relatively recent literature of empirical models in elicited or survey choice probabilities, focusing on the determinants of the adoption of electric vehicles.

The objective of this article is to highlight which improvements in electric vehicles are most likely to affect purchasing intentions of consumers who are not yet convinced to buy an electric vehicle. In doing so, we will be able to identify the most profitable direction for companies' innovative efforts that will enhance their competitiveness. More specifically the key question is whether electric vehicles still lack performance, or companies should just focus on price reduction. The analysis relies on data from a survey concerning 3594 individuals in 6 different European countries - France, Germany, Spain, Italy, Poland and the United Kingdom –carried out between March and June 2012. We have specific information on consumers' purchasing intentions towards electric cars, which is measured as a probability – ranging from 0 to 1 - and not as a dichotomous variable as in most existing surveys. This stated probability to buy correlates with consumers' personal characteristics that are observable only to a certain extent. Furthermore, consumers also choose specific improvements and state the resulting change (increase) in the purchasing probability. This poses interesting methodological challenges. Following Juster (1966) and Manski (1999), we theoretically develop an empirical model, in which the researcher does not observe the realization of the purchasing decision as in a random utility model, but observes, conversely, an ex-ante probability to purchase a specific good. This allows us to borrow from the literature on elicited choice, although the data show some limits since they have been collected with a survey and not generated within a controlled experimental setting. However, the survey design allows us to estimate the impact of specific improvements. Moreover, the key innovative contribution of our empirical model is that we do not focus on the overall distribution of the stated probability, but on the most interesting case for companies and policy makers, that is the probability of switching to the intention to buy (from non-intention to buy) following specific quality enhancements, conditional not only to socio-demographics characteristics, but also to the initial pre-enhancement probability to purchase. As such, consumers who are either already convinced to adopt before any

improvement or who do not change their mind after the improvements as less interesting from a managerial and marketing perspective. Our model can be used to identify the relevant improvements that contribute most to the diffusion of electric vehicles, by focusing on those consumers who switch from non-intention to intention to buy.

The article is structured as follows. Section 2 discusses the literature on the intention to buy, focusing specifically on new green products. Section 3 presents some evidence on the global market for electric vehicles and on the characteristics of the existing products. Section 4 describes the survey data and presents the methodology, deriving the model to be tested. Section 5 shows the results, while Section 6 illustrates the managerial implications and conclusions.

2. What determines the intention to buy a green product?

The literature has widely discussed the determinants of the adoption of innovations, which usually concern the attributes of the technology, the adopters' characteristics, and the features of the social environment. Attributes of the technology refer to technical/aesthetic features and their perception varies depending on the perception of potential adopters (Davis, 1989; Attewell, 1992; Goodhue and Thompson, 1995; Rogers, 2003; Teo et al. 1999; Mole et al., 2004)[1]. Adopters' characteristics concern both personal information (age, gender, nationality etc.) and the degree of individual innovativeness, the knowledge/competences and the experience of consumers (Bettman and Park, 1980; von Hippel, 1986; Goldsmith and Flynn, 1992; Kerstetter and Cho, 2004; Guerzoni, 2010). The impact of the social environment

[1] Some scholars focus explicitly on the concept of perceived risk (Bettman, 1973; Ostlund, 1974; Hirunyawipada and Paswan, 2006), stating that the adoption of a new product (new technology) is a risky decision because there might be undesirable consequences related to the disruption of consumers' existing routines and to possible conflict with existing beliefs (Mitchell et al, 1999).

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can be understood in terms of fads, fashions, and interpersonal influence and network effects (Abrahamson, 1991; Bikhchandani et al, 1992; Roehrich, 2004; Clark and Goldsmith, 2006; Guerzoni and Nuccio, 2014). Indeed, interpersonal communication, whether in the form of word of mouth or in the form of external influence is a crucial mechanism through which individuals get in touch with the innovations.

When measuring adoption, scholars use both purchasing intentions and actual purchasing behaviour (Jamieson and Bass, 1989), although the two phenomena are quite different (Arts et al., 2011). The adoption intention, which is the specific interest of the present paper, is associated with the desire of consumers to purchase a new product: it refers to the consumer's state of mind before the actual purchase takes place and depends on the level of information and perceptions the consumer has at that time. Intentions are typically used to predict the sales of existing products over time, as they are assumed to be good indicators of consumers' purchasing behavior (Sun and Morwitz, 2010; Arts et al., 2011). Research in social psychology suggests that intentions should be the best predictor of an individual's behavior, because they allow each individual to independently incorporate all relevant factors that may influence his or her actual behavior (Fishbein and Ajzen, 1975). In this context, the so-called theory of planned behavior gives insights to predict the variety of intentions and behaviors and has been extensively used to analyse consumers' attitudes towards green products and, in particular, towards electric vehicles.

With reference to the intention to buy and use green products, scholars have looked at the role of emotions, beliefs and values, considering the individual motivations behind pro-environmental attitudes (Barr et al., 2001; Gardner and Stern, 2002; Jansson et al. 2010; Oliver

and Rosen, 2010)[2]. According to Coad et al. (2009), the transition towards cleaner technologies depends both on intrinsic and on extrinsic motivations behind consumer behaviour. Intrinsic motivations concern a personal sense of responsibility, while extrinsic motivations mostly regard financial incentives, but can also include positive social feedback.

Turning to the specific case of electric cars, the literature has widely examined the determinants of the intention to buy an electric vehicle, through discrete choice models that rely either on stated preferences or on actual data (Hidrue et al., 2011; Axsen and Kurani, 2013; Kim et al., 2014). Most studies focus on adopters' demographic characteristics and cars' technical features to explain the adoption process, but some have identified additional determinants of the intention to buy electric vehicles, such as environmental attitudes, information search mechanisms and the overall diffusion of electric vehicles (Ewing and Sarigollu, 2000; Egbue and Long, 2012; Axen and Kurani, 2012; Kim et al., 2014).

For example, Heffner et al. (2007) show that individuals with high levels of environmental awareness choose to buy an electric vehicle as a symbol of their ideas. Using a sample of Californians, Kahn (2007) provides evidence that pro-environmental consumers are on average more likely to purchase hybrid electric cars compared to non-environmentalists and that they are more willing to commute using public transport. Gallagher and Muehlegger (2011) corroborate these results: they found that social preferences for environmental quality and energy security are the most important determinants of consumer adoption of hybrid electric vehicles. In particular, social preferences increased the adoption of green cars more than policy interventions, such as tax incentives. Axsen et al. (2013) investigate the role of social influences in the formation of consumer perceptions and preferences for pro-

[2] In particular, Jansson et al. (2010) show that values, beliefs, norms and habits are important determinants of the willingness to adopt environmental friendly cars.

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environmental technologies, using the example of electric vehicles. They show that a reduced environmental impact of the battery and the possibility to save money on fuel costs are important factors driving consumers' choice. Individual perceptions and the intention to buy electric vehicles are also influenced by public opinion and by individual social networks (Sjoberg, 1998; Lane and Potter 2007; Axen and Kurani, 2012; Kim et al., 2014).

Notwithstanding the importance of pro-environmental attitudes and behaviours, scholars agree that consumers will decide to buy an electric vehicle only if they perceive them to have a better performance compared to conventional vehicles. In particular, Ewing and Sarigollu (2000) show that environmental concerns are important determinants of the intention to buy electric cars, but cannot offset the differences in performance with conventional motorized vehicles, even in the presence of governmental subsidies. They show the inherent technical characteristics of the vehicle - performance, charging time and driving range - are the most important drivers in the decision-making process of consumers. Similarly, Egbue and Long (2012) show that attitudes, knowledge and perceptions related to electric vehicles differ remarkably across socio-demographic characteristics and that environmental concerns influence the adoption of electric vehicles, but less than cost and performance do. Lane and Potter (2007) support these results, showing that ecological issues have little importance in the decision of whether or not to buy a clean vehicle. Oliver and Rosen (2010) find that consumer acceptance of hybrid electric vehicle is limited by the perceived risks associated to the new products and by the trade-offs between different attributes of the electric car, namely vehicle fuel efficiency, size and price.

Considering the above-mentioned issues, policy interventions might decide to favour explicitly the adoption of green cars. The creation of ad hoc fiscal incentives for electric vehicles represents a relevant factor affecting the decision to buy a green vehicle, as well as

government information and advertising campaigns (Diamond, 2009; Driscoll et al., 2013; Sierzchula et al., 2014). However, some argue that, in the context of environmental goods, receiving financial incentives might crowd out pro-environmental behaviours (Thørgersen, 2003).

3. Context: the market for electric vehicles

Electric cars made up less than half of a percent of the 85 million new vehicles sold in the world last year, but the demand has grown so rapidly that the market for the batteries going into these cars is expected to grow more than sevenfold by 2020. The Global Electric Vehicle Outlook (2015) reports on positive trends for global electric vehicle deployment between 2008 and 2014, including strong investment, rising sales and stock totals, the expanded infrastructure for electric vehicle charging, and improvements in battery cost and density. Table 1 and Table 2 show the number of electric vehicles in countries participating in the Electric Vehicle Initiative and the percentage of electric vehicles of new car registrations in selected countries.

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[Table 1 and Table 2 about here]

Governments play an important role both by offering purchase incentives and by regulating the fuel emissions of ICE vehicles. Incentives offered may not increase in the near future, but stronger regulations on fuel economy and emissions will encourage manufacturers to continue to further develop environmentally friendly vehicles. Nevertheless, technological progress induced by environmental regulation seems to be mostly incremental: Heaton and Banks (1997) and Kemp (2000) show that environmental policy instruments rarely lead to radical innovation, but rather support incremental innovation and technological diffusion.

Despite the rapid growth in the market for electric vehicles, the take-off of electric cars has been lower than expected in most countries. Oltra and Saint-Jean (2009) argued that market forces alone would provide insufficient incentives for environmental innovations and that the consumers' willingness to pay for environmental improvements would be too low. The main barriers to the diffusion of electric vehicles are high prices, limited driving range, limited coverage of charging infrastructures and long charging times. Another obstacle to the diffusion is the low level of knowledge of the electric vehicle performances that consumers have (Williander and Stålstad, 2013). Besides the initial higher purchase price, EVs have lower costs per kilometer, considering the present costs of gasoline and diesel fuels (ACEA, 2012). The premium price for the purchase of electric vehicles is assumed to be the most relevant barrier to the widespread adoption. When evaluating the purchase of expensive goods, consumers still try to optimize their utility, attributing a lower importance to environmental issues, which instead play an important role for the adoption of low-cost green products (Diekmann and Preisendörfer, 2003).

All in all, this evidence poses important challenges for marketing green cars. The market is still small, but growing at a fast pace. Companies are competing by differentiating their products, but need to understand which path to follow. Therefore, identifying which features of electric vehicles are the most conducive to the purchase becomes paramount. The number of different models of electric vehicles is increasing. Since 2005, companies like Nissan and Renault have become more aggressive in trying to commercialize green cars (Dijk et al., 2013). The Japanese company, together with its French partner Renault, became the main supporter of the battery swapping technology offered by the Israeli company Better Place. By committing to the deployment of numerous charging points and battery swapping stations Better Place tried to tackle the problem of limited range. The partnership between

Renault-Nissan and the Israeli company also stimulated the search for new approaches and business models for the mass deployment of electric vehicles. Indeed, competition for the development and mass commercialization of green cars grew. The introduction of a series of new models between 2013 and 2014 has intensified the competition and brought down prices. Several new EVs, including the Tesla Model S, Renault Zoe, and Ford Fusion Energy are already bestsellers in their respective markets. Figure 1 plots all the existing models of electric vehicles according to price and performance (driving range in miles).

[Figure 1 about here]

While most models are clustered in the bottom left quadrant, suggesting that most companies are setting (relatively) low prices without investing in performance, Tesla has developed high-performance vehicles, investing in the improvement of technical characteristics. The present study will allow to understand which competitive strategy will pay off.

4. Data collection and descriptive statistics

a. The survey

This article relies on a dataset provided by the European Commission's Joint Research Center that consists of survey results for six European countries (France, Germany, Italy, Poland, Spain and the United Kingdom) conducted in 2012[3]. The direct survey was carried out by IPSOS6 and ~~it has~~had -the aim of reproducing the ideal universe of reference, which is

[3] The data were made available by the Joint Research Centre upon request.

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the population holding a driving license and driving a car[4]. The size of the total sample required was 600 cases for each country and this number was reached on the basis of a series of interviews carried out before the survey and the additional individuals for oversampling frequent car users. The sample was stratified by gender (by age groups), geographical area, city size, level of education and occupational status[5]. A total of 3.723 interviews was carried out (129 during the pilot and 3.594 during the main survey): 3.000 interviews are the base sample (i.e., the representative sample) while 594 interviews are the oversample. A specific weight has been applied to the raw data, in order to rebalance the (deliberate) dis-proportional design of the sample and reproduce the (known) characteristics of the reference universe by country in terms of gender and age, geographical area, size of city or town, education level, and occupational status (Pasaoglu et al., 2012).

-The final database with 3723 observations includes two sets of information coming from the survey: ~~detailed individual variables, such as~~ socio-economic ~~features~~ characteristics of the individuals (age, income, education, occupational status) and data ~~the responses to the questions~~ concerning ~~their~~ individual attitude towards EVs~~.~~

~~The survey is divided into two main sections~~ (for a detailed description see Thiel et al., 2012). ~~The first part~~ In relation to this second set of information, the first part of the survey was specifically designed to understand the familiarity and perception of car drivers towards electric cars. ~~In particular, a~~ A list of statements about electric cars was presented and the individuals were asked to indicate their level of agreement with each statement (1 ="I totally

[4] As mentioned in Pasaoglu et al. (2012, p.9): "*…it was assumed that the profile of people holding a driving license and driving a car does not significantly differ from the universe of the people across age profiles. Therefore, population over 18 years of age could be considered as the best possible approximation to that ideal universe and taken as the operating reference universe for the survey, i.e. the basis for constructing the theoretical sample in terms of quotas.*".

[5] The definition of geographical area and city size is slightly different from country to country depending on the geographic composition of the country (Pasaoglu et al., 2012).

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disagree"; 10 = "I totally agree"). The second part of the survey aimed at understanding how relevant some features of EVs were for the respondents and, most important for the scope of the present article, at measuring their propensity to consider electric cars a realistic alternative in case they wanted to purchase a new car. First, a comparison between a generic conventional car and a generic electric car was proposed in terms of: car purchase price, operating costs (i.e. the cost needed to run the car for 100 km), the range of the car, the time needed to re-fuel/re-charge the car, the maximum speed and the level of 'well-to-wheel' emissions (see Table 3).

[Table 3 about here]

Based on this, respondents were asked to state their intention to buy the electric car in terms of probability (i.e. through a continuous variable ranging from 0 to 1).

The final part of the survey was devoted to understand how the purchase probability varied after the improvement of selected features and the preferences of respondents with regard to the order of improvement. With this aim, respondents were told to assume that they were endowed with a monetary sum (€ 3000) and could use it to improve one of the features of the electric car described before. Then, they were asked to indicate which feature they would improve. This exercise was repeated two more times (three times in total): each time the respondent was allowed to use the money to improve either the same feature as before (e.g. lower the price three times) or a different one (e.g. first lower the price, then increase the distance with one recharge, then improve the speed). Table 4 presents the starting point and the available improvements (at each step) concerning different characteristics.

[Table 4 about here]

Finally, the individuals were presented with a comparison between the conventional car and the electric car with the improvements according to their previous choices, and were asked to indicate the probability of purchasing the improved electric car.

b. Descriptive evidence

~~In total 3723 interviews were collected, 129 in the pilot phase and 3594 in the main survey.~~In the dataset, ~~T~~the distributions of gender and age resemble the population of reference (i.e. citizens holding a driving license) with the only exception being the older population, slightly under-represented. This is due to the nature of the questionnaire, which is targeted at citizens using the car on a daily basis (sporadic car users were eliminated from the sample) (Pasaoglu et al., 2012)[6].

The differences across countries for driving distances are remarkable: in the UK the average is 40 km, Spain and Poland show the highest average with 70 km and 80 km respectively, while France, Italy and Germany are between 50 km and 60 km. This data suggests that the current fleet mostly composed of ICEs could be potentially substituted with electric vehicles since average driving ranges are perfectly compatible with current range and duration of batteries (Thiel et al., 2012). The potential substitution is confirmed also by parking data, since the average parking time during night (i.e. after the last trip reported every day) is about 16 hours (average of all the countries analysed). This length of time is more than

[6] In the sample selection, the Pasaoglu et al.(2012) have been balancing using different variables such as age, occupational status, area of residence, but not the income, which however it is usually well predicted by the other socio-demographic characteristics. Moreover, in the survey, they ask to respondents whether they belong to one of the following classes: high, higher middle, middle, lower middle, low.

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sufficient to fully charge an electric vehicle, even using slow charging methods. However only a minority (about 10%) parked the car in their private garage; this signals that availability of a widespread network of charging stations is vital for mass-market diffusion of electric vehicles.

Individuals were asked to state their familiarity with the electric vehicle technology. The mean score (all countries) is 5.5 where 1 means "no knowledge at all" and 10 "full knowledge". Poland shows the lowest scores with 71% of respondents not familiar with electric vehicles, while in Italy and Spain more than half of the respondents declared they had at least some degree of familiarity. In particular, respondents were asked to express their knowledge on 10 different statements on electric vehicles. Overall citizens correctly agree on the fact that electric vehicles are expensive, that they have no tailpipe emissions, that they are silent and safe. Furthermore, they demonstrate they understand the negative impact on the environment of road transport. However, some misconceptions emerged since a vast majority (43%) does not know the cost of driving 100 km with an electric vehicle and is not able to express an idea on charging times. Some respondents are not aware of the existence of fast charging methods, already available on the market.

As far as the intention to buy is concerned, Figure 2 displays the probability of purchasing an electric vehicle. The mean probability for all the countries is 38.4%, and the median 35%. Hence the distribution is skewed to the right, particularly for the United Kingdom, France and Germany. Italy, Spain and Poland instead show a more centred distribution. However, the distributions shown in the box plots are rather dispersed. The lowest purchase probability is that of the United Kingdom, followed by France and Germany. In these countries, the majority of respondents show a probability of purchase lower than 30%. Moreover we see that the third quartile in the United Kingdom and France is below 50%

probability of adoption, a bit higher in Germany. The median for Italy, Spain and Poland is instead higher indicating an overall higher propensity towards the adoption of electric vehicles.

[Figure 2 about here]

The survey identified five attributes that could be improved by consumers: (1) Price, (2) Driving range, (3) Recharging time, (4) Recharging at home, (5) Speed. We investigate how the preferences on attribute improvements influence the intention to buy and we delve into the descriptive evidence to gain an insight into consumers' behaviour. Figure 3 shows the distribution of the choice of the first improvement by country. Reducing the price and having longer driving ranges are the top priorities with an equal score of 32% (average across countries). A lower purchase price (Attribute 1) is the most important improvement for Italian, French and Spanish consumers, while the driving range (Attribute 2) is considered to be more important in the UK and Germany. In Poland the highest priority was given to the possibility of recharging the vehicle at home (Attribute 4), which is also important in France. Speed (Attribute 5) as well as the recharging time (Attribute 3) are not important factors to explain the intention to buy.

[Figure 3 about here]

After the completion of the three rounds of improvements, many possible combinations appeared. Figure 4 plots the distribution of the choices on all the possible combinations of improvements across the three rounds. 11% of the total respondents chose just to reduce the purchase price (allocating the €3000 to price reduction for three times) and this combination (1-1-1) is by far the most frequently chosen one. The second most popular combination was improving the driving range for three times (2-2-2), while the third preferred a combination

involved a mix of recharging at home, improving the driving range and reducing price (4-2-1).

[Figure 4 about here]

As a consequence of improvements, the intention to buy (purchase probability) also changed.

5. Methodology and empirical analysis

The aim of this paper is to assess which product characteristics should be improved to increase the diffusion of electric vehicles, in other words which preferred stated improvement by consumers might lead to a more likely actual purchase.

Researchers have often investigated to what extent stated intentions and actual purchasing are related and, in the case of negative correlation, have looked at the reasons for existing differences. First, there are biases in the way in which consumers report their stated intentions (Balasubramanian & Kamakura, 1989; Kahneman & Snell, 1992). Biases might come from different sources. In particular, consumers tend to over-report desirable behaviours and under-report undesirable behaviours (Bagozzi, 1994; Bagozzi, Yi, & Nassen, 1999), they often overestimate their demand (Klein et al. 1997), or might be conditioned by the answer order. Second, even when reports are not biased, variables affecting the intentions to purchase might change over time, thus creating changes in the actual purchases (Infosino, 1986; Morwitz et al., 2007; Sun and Morwitz, 2010). Furthermore, the relationship between intention to purchase and subsequent behaviour may differ across different groups

of people (Morwitz and Schmittlein, 1992). Finally, there is a systematic imperfect correlation between intentions and actions (Bagozzi & Dholakia, 1999; Gollwitzer, 1999).

Purchase intentions are asked either as a direct question ("Do you intend to purchase product x?") or in probabilistic terms ("How likely are you to buy product x?") using a different intentions scale (Infosino, 1986; Morwitz and Schmittlein, 1992; Armstrong et al., 2000), or in terms of the preferred alternative among more goods (Louviere, 1994). Assessing intentions with purchase probabilities partially solves the problem of overstatement of purchase intentions for new products and allows us to better describe situations where people may not have planned a purchase, but realize that they may do so in the near future (Armstrong et al., 2000; Carson and Groves, 2007).

The analysis of purchase intention by Wright and MacRae (2007) shows that purchase intentions for products exhibit biases and small confidence intervals will always result in individual inaccuracies. This highlights the importance of a larger sample size and the need to fit models against multiple data sets. This finding also shows that purchase probability scales performed better than purchase intention scales. The greater precision of probability scales suggests that they may be more useful both as direct measures of likely behaviour and as dependent variables in consumer behaviour research.

Starting from these considerations, we develop an empirical model, which can fully exploit the information in the dataset in an innovative way and investigates the factors that determine a shift in consumers' stated preferences in relation to the intention to buy an electric car.

Our starting point is the traditional random utility approach, in which a consumer purchases a product when the utility deriving from the good is higher than a given threshold corresponding to the utility of not purchasing (i.e. of purchasing an outside option). The utility is a function of *x,* a set of product characteristics and consumers' characteristics, and a random term *u*:

$$y^*_i = x'\beta + u \quad with \quad E(u) = 0 \qquad (1)$$

In the usual empirical setting, the researcher does not observe the utility y^*_i, but the actual purchase y_i. y_i is assumed to be a random dichotomous variable for the individual *i*, which takes value 1, when the utility evaluation of the consumers exceeds the threshold τ and the individual therefore purchases, and 0 otherwise:

$$y_i = \begin{cases} 1 & y^*_i > \tau \\ 0 & y^*_i \leq \tau \end{cases} \qquad (2)$$

While the researcher cannot measure the utility y^*_i, she observes the realization of y_i and the set of covariates *X*. It is therefore possible to estimate the impact of the covariates on the probability to buy. In the random utility model, τ is often assumed to be zero[7], without any loss of generalization. In our model, we consider τ as the utility of the outside option.

In the present setting, we depart from the traditional approach, by making use of the intention to buy, as revealed by individuals in the form of probability ranging from 0 to 1. The idea dates back to the work of Juster (1966), who first surmised that purchase intentions underperform in predicting the actual purchasing rate since they do not measure movement among non-intenders, which in the case of innovative products are the vast majority. The idea is also based on Infosino (1986), who interprets purchase intention ratings as related to

[7] The literature on latent regression model for continuous variables or index function modelling suggests various ways to treat explicitly also individual varying thresholds, since the introduction of the ordered probit model (McElvey and Zavoina, 1969). However, in adoption binary exercises, the standard micro-econometric approach consider tau equal to 0 (Cameron and Trivedi, 2005).

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the willingness to pay, reflecting tastes/preferences and income, and to the product value, which is the difference between willingness to pay and product price and measures the extent to which a consumer likes a specific product/price combination. Manski (1999) suggested an econometric model to estimate consumers' preferences from elicited choice probabilities. He argues that consumers place a continuous subjective distribution on u which, in his words, captures a resolvable uncertainty over the characteristics which are not stated in the survey scenario but will be likely to exist in the actual purchase:

$$q_i = Q(x'\beta + u) \qquad (3)$$

In an experimental design, in which consumers state their probability over different sets of attributes, Blass et al. (2010) are able to derive preferences for electricity reliability in Israel using elicited choice probabilities. Contrary to stated choices, choice probabilities allow consumers to express uncertainty about their actual behaviour and provide more information to researchers.

The simple estimation of Eq. 1 runs the serious risk of finding spurious relationships, since it is highly likely that consumers' unobserved characteristics, such as ~~for instance~~ the existence of a latent bias for green products, correlate with both their characteristics and their stated intention to buy. Therefore, as an additional point of departure from the standard literature, we exploit the full information of the dataset and manage to bypass this endogeneity issue. As mentioned before, in the survey respondents first declared their intention to buy $y^*_{i,t}$, then chose three different improvements they are willing to pay for in order to improve the characteristics of the vehicle, and then they stated again their intention to buy, $y^*_{i,t+1}$. We can interpret the variation in the intention to buy after the chosen improvements as an

increase in the utility only due to change in the product characteristics. Thus, we observe the stated probability of each individual at two different times, whereas, in between, the only change in the context is the choice of improvement made by each respondent. In this way, we have a controlled experiment, in which the endogeneity problem is much milder. We still cannot rule out that some unobserved heterogeneity correlates both with the intensity of change in the utility and with the choice of the improvement. However, we raise the bar of control of the empirical exercise much more than any other comparable analysis.

Figure 5 depicts a scatter plot of the pre-improvement utility q^*_i and of the post-improvement $q^*_{i,t+1}$ utility for each consumer *i* and captures the change in the stated utility.

[Figure 5 about here]

The points on the main diagonal represent individuals who did not change their evaluation after the improvements, while the horizontal distance of each point from the diagonal measures the positive change in the stated utility after the improvements. Data points above the diagonal denote consumers who reduce their stated utility after the improvements[8].

In the same figure, for any value of τ, we can identify 4 quadrants (as an example, in the above figure we have highlighted a value of τ = 75%) that represent different types of consumers. In this way, we are able to segment the market and gather more precise information on the characteristics of different groups. The bottom-left quadrant isolates consumers with a low intention to buy both before and after the improvements. They do not cross the threshold even after three subsequent improvements of the vehicle. In the top-right

[8] We consider these individuals as being non reliable and removed them from the sample.

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quadrant, we observe consumers with an above-threshold utility even before the improvements. The top-left quadrant is empty by construction, while in the bottom-right quadrant we observe consumers who crossed the threshold as the result of the improvements. In other words, while some consumers will never adopt an electric vehicle regardless of its improvements and some others are already persuaded before the improvements, there exist a target group of consumers, whose intention to buy was below the threshold before the improvements and can switch to adoption due to the improvements. This is a particularly interesting group for companies and policy makers who are willing to identify which are the triggers to adoption of electric vehicles. We focus both on the choice of the specific product improvement and on the individual characteristics of those consumers. Both product improvements and policy incentives willing to increase the diffusion of electric vehicles should focus on those product characteristics that are relevant for the target consumers who are likely to adopt following those changes.

In order to detect the impact of the choice of improvements on the likelihood of crossing a specific threshold τ as the result of these choices, we estimate the following regression model for each possible value of τ (81 regressions in total, with $\tau \in [10;90]$)

$$\Pr(q_{i,\,t+1} > \tau \,|\, q_{i,t} \le \tau) = F(x) \;\; with \;\; F(x) = \frac{1}{1+e^{-(x'\beta)}} \;\; and \;\; \forall \tau \qquad (4)$$

where X is a set of covariates which describe all the possible improvements and individual socio-demographic characteristics.

Concerning the improvements, we include three categorical variables that indicate, for each consumer, what was the choice on the first, the second and the third improvement among the five possible choices at each step. As a robustness check, we also run a model where we include a categorical variable with the most likely 20 combinations of improvements.

We include a set of control variables, which measure any possible sort of unobserved heterogeneity. The literature has often emphasized that the relationship between the intention to buy and the actual purchase may differ across groups of people. In particular, demographic and product-usage related factors moderate the intention-behaviour linkage (Morwitz and Schmittlein, 1992). Therefore, we first include into the regression a set of socio-demographic variables - gender, education, age, income, and country of origin. Second, given that the object of our investigation is –electric vehicles, we add a set of individual controls that capture the attitude towards the cars and towards the environment: the number of cars driven, the use of solar panels, the living area, the driving frequency, and the engine size of the currently owned vehicle. Finally, we include the initial distance from the threshold, since, ceteris paribus, the closer a consumer is to the threshold, the more likely he or she is to switch after the improvement.

6. Results

We implemented the empirical model in R using the package GLM with the Fisher scoring algorithm for solving numerically the maximum likelihood problem of the logit estimation. Since we run each regression for 81 different values of τ, with $\tau \in [10;90]$ and $\tau \in \aleph$, and for many categorical variables, we report a set of tables with the full regression outcomes for three selected values of τ in the Appendix A1. As far as the control variables are concerned, in each regression we control for all the factors, but we show here the odds ratio of each factor of the most interesting covariates over the set of values of τ. We use a dotted line when the significance level of the results is below 95%. All the results of our model also hold

when we include a categorical variable with the most likely 20 combinations of improvements as a robustness check.

Figure 6 reports the effect of the country of origin on the probability to switch from non-intend to buy to intend to buy for different levels of τ. Spain is taken as reference category and set to 1. Being from the UK has a significant (lower) impact on the switch for high values of τ, while the same hold for Germany for low values of τ.

[Figure 6 about here]

Figure 7 and Figure 8 show the probability of switching to the intention to buy an electric vehicle by income and educational level (age). In line with the existing literature (Hidrue et al., 2011; Axsen and Kurani, 2013), we do find differences across different segments of the population. In particular, more educated and richer people are more likely to switch from below to above the threshold.

[Figure 7 and Figure 8 about here]

As expected, the distance from the threshold is significant and has a negative impact on the probability to switch, while the other controls turned out to be non-significant for almost any value of τ.

We now turn to the core of our empirical analysis, looking at how the choice of a specific improvement affects the probability of switching from the non-intention to the intention to buy an electric vehicle. Our approach permits us to test how the perceived behaviour control can be used to study the perception of individuals and how they can grasp the novelty

(Moons and De Pelsmacker, 2012), particularly in the case of green products. Figures 9, 10 and 11 show the impact of the choice of different improvements on the probability of switching to the intention to buy an electric vehicle in the first, second and third step. We can safely assume the first choice to be the priority for the respondents and this evidence is also strengthened by the fact that the significance levels are much higher in the first than in the subsequent steps, as if the first choice mattered more in affecting the probability to switch to the intention to buy. The results for the second and third improvement do not differ too much, albeit they exhibit less statistical significance.

[Figure 9, Figure 10 and Figure 11 about here]

The overall picture is very neat. The analysis suggests that the most important factor for persuading a consumer to adopt is price, while an increase of maximum speed has a minimal impact on the probability of switching from the non-intention to the intention to buy. This result aligns previous findings which highlight the effect of financial incentives and increase infrastructure on the probability to buy electric vehicle (Sierzchula et al. 2014). As far as the other triggering factors are concerned, there are important differences across different thresholds. For low values of τ, the driving range (i.e. the duration of the battery) is the most important improvement after price, while for higher values of τ, the possibility of recharging at home is to be the second most important driver of adoption.

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Compared to the existing studies on the probability of adopting an EV, our analysis focuses mostly on the relevance of the car attributes and the results are partially in line with previous analyses that show how cost concerns and product technical characteristics – driving range in particular - are two important determinants of the intention to buy an EV (Ewing and Sarigollu, 2000; Egbue and Long, 2012). However, in our analysis we highlight that price offsets other attributes in affecting the decision-making processes of consumers and we also

are able to distinguish the importance of different attributes according to the initial individual attitude towards EVs. Hidrue et al. (2011) also highlights the importance of the price, but they can derive their implication only in relation with the cost of gasoline, while in our approach we show that price matters ceteris paribus more than ~~nay~~any other improvement in the vehicle caracteristics.

Furthermore, to our knowledge this is the first attempt to investigate not simply the determinants of the intention to adopt an EV, but to get a more fine-grained understanding of the factors that persuade consumers who have a low probability to buy to change their mind.

Commentato [c3]: che dite se mettiamo questo paragrafo in introduzione ?

~~Overall the results suggest that manufacturers should directly take actions to increase the diffusion of electric cars, by engaging in technological development that will reduce the cost of production (and hence the price) and improve the quality of batteries, thus increasing the driving range. Furthermore, governments might provide financial incentives for consumers who are willing to buy electric vehicles, but should also provide more knowledge and information about the possible long term benefits deriving from the adoption of electric vehicles.~~

This paper has investigated the intention to buy electric cars, in order to assess which factor is most likely to trigger their widespread diffusion. In doing so, it has looked at the impact of different possible improvements – price reduction, increase in the driving range, recharging time, possibility of recharging at home, increase in maximum speed - on consumers' propensity to purchase an electric vehicle and has examined, in particular, those consumers who shift from non-intention to intention to buy after the product enhancements. Using data from a survey of European individuals, we have employed an original methodology,

treating the stated intention to buy as the utility deriving from the actual purchase. We observe the stated utility of each consumer at two different times, whereas, in between, the only change in the context is the choice of improvement made by each respondent. We therefore are able to interpret the variation in the intention to buy after the chosen improvements as an increase in the utility only due to change in the product characteristics.

Results show that price reduction is the most important triggering factor for the diffusion of electric vehicles, as it determines more than other factors the transition of consumers from the non-intention to the intention to buy an electric vehicle. As for the other possible quality enhancement, the improvement in the driving range constitutes the second most important factor for low initial values of the stated intention to buy, while the possibility of recharging at home seems to matter significantly more for consumers with high initial values of the intention to buy. Overall the results suggest that manufacturers should directly take actions to increase the diffusion of electric cars, by engaging in technological development that will reduce the cost of production (and hence the price) and improve the quality of batteries, thus increasing the driving range. Furthermore, governments might provide financial incentives for consumers who are willing to buy electric vehicles, but should also provide more knowledge and information about the possible long-term benefits deriving from the adoption of electric vehicles.

The empirical methodology and findings have important implications both from a managerial and from a policy perspective. First, we draw the attention to the fact that firms should focus on product quality improvements that matter for all the potential population of adopters, but specifically for those consumers who are most likely to switch from non-intention to intention to buy following those changes. We do show that the probability of switching to the intention to buy an electric vehicle is particularly high for high income and

more educated people. Second, the importance of price reduction across different values of the initial stated preference suggests that companies should engage in the development of new technologies and production processes that lower the cost of production. As consumers look for price reduction, an additional managerial implication would concern the development of smaller electric vehicles that can be affordable for a larger set of the population. At the same time, the provision of financial incentives from the governments could also represent an important trigger for the initial diffusion of these new cars. However, concerns about prices can also be the result of lack of information and knowledge about the long-term benefits of electric vehicles that mostly regard savings on fuel and the reduction of emissions. Therefore, public campaigns to provide accurate information and knowledge about these advantages would certainly reduce the importance of purchase price as opposed to other factors. Third, besides the general agreement on the need for price reduction, differences in the initial stated intention to buy drive diverse choices on other types of improvements. This means that companies should think about strategies of product differentiation that satisfy the needs of very heterogeneous consumers.

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Appendix

[Table A1, A2 and A3 about here]