JOURNAL OF LAW AND ECONOMICS
ISSN 2709-8133
SEP. 2021 VOL. 2, NO. 3

A Bigger Driver of Electric Car Adoption: Fiscal Stimulus or Technological Innovation

Nykvist Muñoz
University of Turin

ABSTRACT

Although the low EV uptake depends on both demand and supply factors, this paper focuses on the demand side and more specifically on the drivers' preferences for EVs. We designed and administered stated preference interviews at national level, collecting data from a sample of 996 respondents. We explore the main determinants of consumer preferences such as gender, age, education, family income, car ownership, garage availability, BEV knowledge, and attitude towards the environment. To this aim, we estimate a multinomial logit (MNL) and a random parameter logit (RPL) model including as variables such as purchase price, fuel economy, driving range, charging time, fast charging density and free parking. We estimate the models also in the Willingness To Pay (WTP) space, and compare the results with previous Italian and international studies. Finally, we perform a scenario analysis comparing the impact of financial policies vs. technological improvements.

KEYWORDS

Car choice; Electric car; Stated preference; Discrete choice model; Scenario analysis.

1. Introduction

Italy and several Southern and Eastern European countries, however, would greatly benefit from the lower air pollution emissions associated with EVs. Italy, for instance, has the highest levels of air pollution among the EU countries, especially in the densely populated Po Valley regions, where the climatic characteristics and a morphological landlocked position lead to PM10, PM2.5, O3, and NO2 concentration levels well-above the air quality standards set by the European directives. The paper adds to the already abundant international literature on consumers' preference for EVs and to the much limited Italian literature, which includes, to be best of our knowledge, only Valeri and Danielis (2015), Valeri and Cherchi (2016) and Giansoldati et al. (2018). Compared to previous Italian studies, it does not innovate in terms of the type and number of attributes considered. This lack of innovation, however, turns out to be an advantage since it allows investigating the evolution of the preference structure of the Italian drivers as EVs penetrate the market, an issue that has found

little coverage in the literature. Compared with the previous Italian studies, this paper is characterized by a larger sample size (N = 996) and a stronger attention on sample representativeness.

2. Related Literature

The literature on EVs has been growing exponentially in the last years. Papers investigated several issues including vehicle design and performance, charging infrastructure (electricity load distribution and management, charging infrastructure resilience), potential environmental benefits (electricity generation mix), and car manufacturers' business models and marketing strategies. A large set of papers have adopted the consumers' perspective, analysing the total cost of ownership, range anxiety, charging behaviour and taking into account consumers' heterogeneity with regards to the psychological characteristics, symbolic attributes, and environmental concern and awareness. Many papers analysed the impact of national and local governments' policies such as purchase-based incentives, use-based incentives and direct regulations. For a recent synthesis and classification of the 239 studies published in scientific journals, see Kumar and Alok (2020).

Instead of using cohort type surveys, other authors compare among studies via meta-analytical approaches. Dimitropulous et al. (2013) study the WTP for driving range. They do not investigate whether it varied over time but they detect variations among countries (the average WTP for the driving range in the USA being more than twice as high as in Europe). Greene et al. (2018) review 52 U.S.-focused papers with sufficient data to calculate WTP values for 142 different vehicle attributes, which they organized into 15 general groups. They find that, although the means and medians of the marginal WTP of the attributes generally agree on signs, the variability in estimates across studies is almost always very large and is affected by a variety of factors, some under the researchers' control and others not. They find systematic differences between studies using stated versus revealed preference data and between those employing random versus fixed coefficient models.

This paper adds new evidence on the Italian consumers' preferences for EVs. There are both similarities and differences with the previous studies. Similarly to Giansoldati et al. (2018), hypothetical choices are restricted to electric and petrol cars in order to simplifying respondents' task and focus their attention on EVs. The vehicle attributes are the same, while a charging time attribute and a policy attribute (free parking) are added. Differently from the previous studies, all questionnaires are internet-based. Such a choice allowed us to extend the sample size (N = 996) and control the survey representativeness across regions, age, and gender. The addition of new Italian evidence allows us to compare among studies and detect changes in the Italian consumers' preferences over time.

3. Stated Choice Experiment and Data Collection

The survey consisted of internet-based interviews, administered in the period October-December 2018 to a representative sample of the Italian population by SWG s.r.l. (https://www.swg.it/), a Trieste-based company performing since 1981 market research, opinion and institutional polls, and sectoral studies. SWG s.r.l. relies on a sample of selected Italian respondents who are paid to participate to their surveys. We developed a questionnaire, defined the design and provided the company with a list of selection and segmentation criteria. We focused only on driving license holders, and asked for a representativeness of the sample in terms of residence (region and city size), age, gender, and education level. Based on our budget, we agreed on the minimum number of internet-based questionnaires to be collected. The survey resulted in 996 valid interviews.

The questionnaire consisted of two parts. In the first part, respondents were asked to provide socio-economic data including personal information, car and garage availability, car mobility habits, EV knowledge, and environmental awareness.

The age distribution is also ± 10% representative of the Italian population. The distribution by city is close to the actual proportion for the medium sized cities, while it is slightly under-represented for the small towns (under 10 thousand inhabitants, 21% vs. 33%) to the advantage of the large towns (over 100 thousand inhabitants, 37% vs. 23%). The predominant level of education is high school diploma. Most of the respondents are white collar workers, earn less than €70,000 per year, and a large proportion of them states that their income allows living comfortably. A large proportion of the families owns two cars. About 70% of the respondents own a garage. With regard to the average number of kilometres travelled per day, almost all respondents travel well within the current EV driving range. Only 3% travel more than 100 km per day. In terms of the average number of kilometres travelled per year, 16% of the respondents drive more than 20 thousand km per year (which is a threshold that makes EV cost-competitive with the conventional cars; see Danielis et al., 2018). More than a third of the respondents drive between 10 and 20 thousand km per year (the Italian average is about 10,250 km) and 48% less than 10 thousand km per year, which makes EVs hardly competitive at the current purchase prices (Scorrano et al., 2019, 2020a). Almost all respondents perform trips longer than 400 km less than 10 times per year.

The second part of the questionnaire consisted of 12 hypothetical choice scenarios similar to the one illustrated in Fig. 1. The selection of the attributes to be included in the stated choice experiments is a critical choice for a stated preference study. The number of potential attributes is very large and their specification is differentiated in terms of metrics. As quoted, Greene et al. (2018) identify 142 different vehicle attributes, which could be organized into 15 general groups (comfort, fuel availability, fuel costs, fuel type, incentives, model availability, non-fuel operating costs, performance, pollution, prestige, range, reliability, safety, size, and vehicle type). In order to prevent respondents' fatigue and cognitive burden (Hensher, 2006; Hess et al., 2012a), the task for a researcher is to select a subgroup of them, which is both relevant for the choice process and of potential interest to car manufacturers or policy makers in their effort to promote EV uptake. We selected the following attributes: purchase price, fuel economy, driving range, the time required for a fast charge, the maximum distance between fast charging stations and free parking. We made this choice after reviewing 36 primary studies investigating consumer preferences for EVs from 1980 onwards (Giansoldati et al., 2017) and integrated them with information drawn from reviews by Coffman et al. (2016), Liao et al. (2017), and Greene et al. (2018). Contrary to most studies, we decided to use specific car models and brands currently available in the Italian market to increase the realism of the choice scenarios. The brand\model attribute captures features such as comfort, style, prestige, safety, size, and vehicle type. We selected 5 pairs among the best-selling EVs in Italy in 2018 and compared them with their petrol counterparts. The EVs are the BMW i3 125 kW 94 Ah, the Volkswagen e-Golf 2018, the Renault Zoe Life Q90, the Nissan Leaf 40 kWh Visia Plus and the Daimler Smart forfour Electric Drive Youngster. Their petrol equivalents are the BMW Series 1 116i 5 doors, the Volkswagen 1.0 Golf TSI 85 cv Trendline BlueMotion, the Renault Clio 1.2 Zen, the Nissan Qashqai 1.2 DIG-T Visia, and the Daimler Smart forfour 70 Twinamic Perfect. Their picture was also provided to remind respondents the shape and size of the proposed models, asking them to base their choice only on the selected attributes irrespective of colour, trim, tires type, etc. We decided not to include the Tesla Model S and Model X, although they occupied the fourth and the fifth position in 2018, since we chose to focus on the more popular small \medium car segment (UNRAE, 2019) .

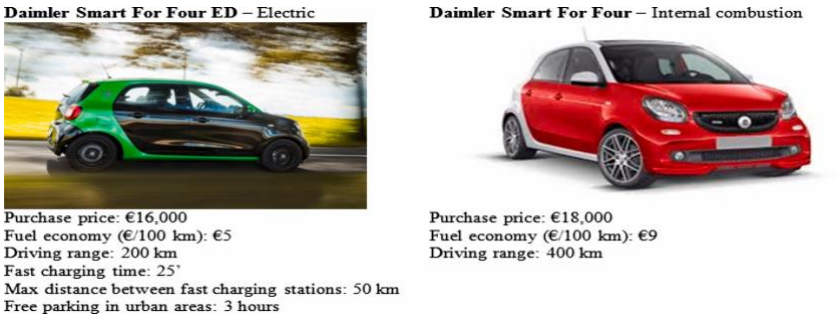

Figure 1. Example of a stated preference choice proposed to the respondents.

4. Econometric Estimates

All attributes are significant and have the expected sign, exception made for the Max distance between stations with fast charge. The coefficient associated with the ASC_EV indicates that, ceteris paribus, Italian respondents have a positive attitude towards EVs. The coefficients of Purchase price and Fuel economy are both negative and largely significant. We find that the coefficient of the EV range is more than three times larger than that of the Petrol car range, confirming the findings of Valeri and Danielis (2015) and Giansoldati et al. (2018). Among the brands\models, the Daimler Smart forfour is the least preferred, in line with the previous findings by Giansoldati et al. (2018). The coefficient associated with the attribute Fast charging time is negative and significant, consistent with the findings by Hackbarth and Madlener (2013; 2016). The variable Free parking is significant as in Abotalebi et al. (2019). On the contrary, the variable Max distance between stations with fast charge, against our expectations, is not significant. Such a result might have several explanations. The first is technical: because of the large number of attributes, this attribute, being the one before the last, failed to catch the attention of the respondents (Hensher, 2006 ; Hess et al., 2012a). The second explanation, more likely in our view, reflects a still incomplete knowledge among our respondents of the charging issue in the EVs daily use. They might be unable to distinguish among the various charging speeds or they might simply deem the issue unimportant.

As already mentioned, the RPL specification allows for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time or individuals. After experimenting with many alternative variable specifications, we report in Table 1 three specifications. The first two are estimated in the preference space, while the last one in the WTP space.

Next, in columns 3 and 4 (Table 1) we illustrate how the estimates change when we interact the Purchase price and the EV range attributes with EV Knowledge. The overall significance of the model slightly improves (in terms of Adjusted Rho-square and AIC but not in terms of BIC), the coefficients of the interaction terms are significant and indicate that EV knowledge decreases both the price and the range sensitivity. The implication is that the more a person knows EVs the less stringent are her\his price and range requirements, which is promising for the EV uptake in Italy.

In June 2017, Giansoldati et al. (2018) collected SP data using a questionnaire similar to the one reported in this paper with two main differences. They used 4 car models, i.e. the Volkswagen e-Golf, the Renault Zoe, the Nissan Leaf and the Daimler Smart forfour Electric Drive, selected among the best-selling cars in Italy in that year, but they did not include the BMW i3 as in the survey reported in this paper. They included some similar attributes (i.e., purchase price, driving range, the time required for a fast charge, the maximum distance between fast charging stations) except for free parking and fuel economy.

Moreover, the sample population is different both in terms of number and composition. Giansoldati et al. (2018) administered the questionnaire in June 2017 to 318 individuals, 18.3% of which have had an EV driving experience, whereas the current paper collected data in October-December 2018 from 996 individuals, 16% of which had an EV driving experience.

Because of the theoretical flaws indicated above, these results must not be taken as a proof, but simply as an indication that some of the non-monetary barriers that adversely affected the preference structure for EVs of the Italian drivers might have weakened. This is most likely due to the information circulated in the public debate and to the growing direct and indirect experience facilitated by the growing EV uptake. Changes in the preference structure are not uncommon in the case of innovative products such an electric car as illustrated in the literature. However, their empirically-sound analysis should be planned and carried out appropriately in order to prove our hypothesis.

Table 1. Results of the RPL model specification.

	RPL (preference space)		RPL (preference space) with EV knowledge interaction		RPL (WTP space)	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Random parameters ASC_EV	1.244***	3.6	0.817**	2.0	1.358***	5.5
SD of ASC_EV	0.997***	12.9	0.997***	13.4	0.41***	4.3
Purchase price (€ 10,000)	−1.65***	−24.7	−1.875***	−19.9	−1.698***	−19.5
SD of Purchase price	0.96***	20.8	0.955***	20.8	1.592***	18.7
EV range (100 km)	0.51***	12.0	0.779***	8.6	0.204***	6.6
SD of EV range	0.128*	1.9	0.126**	2.0	0.187***	6.7
Fixed parameters						
Fuel economy (€ per 100 km)	−0.049***	−5.8	−0.034***	−3.5	−0.038***	−6.0
Petrol car range (100 km)	0.128***	8.9	0.164***	9.3	0.05***	4.7
VW vs. Daimler	1.066***	9.7	0.82***	6.2	0.464***	7.7
Renault vs. Daimler	0.836***	11.6	0.664***	7.6	0.53***	10.4
Nissan vs. Daimler	1.044***	11.7	0.863***	8.2	0.465***	10.3
BMW vs. Daimler	0.974***	9.9	0.907***	9.0	0.572***	9.4
Fast charging time (minutes)	−0.011***	−5.1	−0.01***	−4.5	−0.009***	−6.4
Max distance btw charging stations (km)	0.002**	2.0	0.005***	3.5	0	−0.5
Free parking (hours)	0.015***	5.4	0.018***	6.2	0.006***	3.3
Socio-economic variables Age	0	0.1	0	0.1	−0.006**	−2.2
Level of education	−0.002	−0.1	−0.002	−0.1	−0.027*	−1.9
Family members with license	0.062	1.3	0.061	1.3	0.016	0.5
Owned garage	−0.092	−0.9	−0.091	−0.9	0.042	0.6
Trips longer than 400 km per year	−0.013***	−2.9	−0.013***	−2.9	−0.005	−1.1
EV knowledge	0.018	0.6	−0.06	−0.7	0.037*	1.7
EV driving experience	0.002	0.0	0	0.0	−0.071	−0.7
Environmental concern	0.334***	2.7	0.334***	2.7	0.133	1.5
Environmental association	−0.326***	−4.6	−0.326***	−4.6	−0.232***	−4.5
Interacted attributes						
Purchase price*EV knowledge			0.099***	3.4		
EV range (100 km) *EV knowledge			−0.056***	−2.8		
Model diagnostics n (observations)	10,728		10,728		10,728	
k (parameters)	24		26		24	
Draws	1000		1000		1000	
LL (start)	−7436		−7436		−7436	
LL (final)	−5897		−5889		−5925	
Adj. Rho-square	0.2036		0.2044		0.1999	
AIC	11,843		11,831		11,898	
BIC	12,018		12,021		12,073	

5. Conclusion and Policy Implications

In this paper, we report the results of a survey aimed at investigating consumers' preferences in Italy. This paper complements the international literature and updates previous Italian surveys administered by the authors in the past years (Valeri and Danielis, 2015; Giansoldati et al., 2018). Based on the MNL and RPL model specifications, we confirm that vehicle attributes such as purchase price, fuel economy, and driving range play a very relevant role. With regards to the attributes related to charging, we find that the time spent to fast charge the vehicle affects the respondents' utility, while the fast charging network density carries a counter-intuitive sign or is not significant. The limited experience with EVs of our sampled respondents may explain such a result. This aspect of the choice process, however, deserves more research as the EV knowledge progresses. The only policy attribute introduced into the choice scenario, i.e. the possibility to enjoy free of charge parking, significantly influences the choice between the two alternatives.

Comparing our estimates with previous Italian studies, in particular with Giansoldati et al. (2018), which use a similar questionnaire but on an earlier and more limited sample, there are hints of a variation in the perception of the Italian drivers towards EVs. A noticeable difference is the ASC_EV coefficient, which represents, ceteris paribus, the respondents' attitude towards EVs. Giansoldati et al. (2018) find a negative value while this study finds a positive one. At international level, positive ASC coefficients for EVs are also uncommon. Among the most recent studies, only Mabit and Fosgerau (2011) and Langbroek et al. (2016) report positive coefficients. This finding might indicate a change in the Italian consumers' perception with regard to EVs, however it deserves to be properly investigated using a cohort approach. A second interesting finding is that the WTP for a 1-km increase in the driving range is lower than that in previous studies, indicating that Italian consumers are becoming more confident on EV driving range.

The scenario analysis provides us with further useful indications on the impact of financial incentives and technological improvements. We find that in Italy the former would have a larger impact on the probability of buying an EV, increasing it on average by 15.5% with respect to the baseline scenario, while the technological improvements would increase it by only 5.5%. This result indicates a high price sensitivity of the Italian customers and it leads us to argue that cheap and small EVs with limited driving range would be preferred to expensive sedans with larger batteries. They would suit well the mobility needs of Italian users and adapt to the limited parking space available in the Italian cities. In light of these considerations, we advise car manufacturers who wish to expand their market share in Italy to develop affordable electric city cars. So far, the only available models have been the Smart ED and the Renault Zoe, but with a purchase price relatively high compared to their petrol counterparts.

Finally, in this paper, because of the constraints of our survey, we were not able to deal in-depth with the issues of objective and subjective knowledge, attitudes and perceptions. Faced with the trade-offs between survey simplicity\respondents burden and completeness, we were not able to gain a thorough understanding of the interactions between knowledge, attitudes, perceptions and choice. Hybrid choice logit models might help shed more light on this topic, although specific surveys focused on these complex interactions might be required.

References

Cameron, T.A., James, M.D., 1987. Efficient estimation methods for" closed-ended" contingent valuation surveys. Rev. Econ. Statist. 269–276.

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. Transport. Res. Part D: Transport Environ. 18, 39–45.

Carley, S., Siddiki, S., Nicholson-Crotty, S., 2019. Evolution of plug-in electric vehicle demand: Assessing consumer perceptions and intent to purchase over time. Transport. Res. Part D: Transport Environ. 70, 94–111.

Greene, D., Hossain, A., Hofmann, J., Helfand, G., Beach, R., 2018. Consumer willingness to pay for vehicle attributes: What do we Know? Transport. Res. Part A: Pol. Pract. 118, 258–279.

Jenn, A., Lee, J.H., Hardman, S., Tal, G., 2020. An in-depth examination of electric vehicle incentives: Consumer heterogeneity and changing response over time. Transport. Res. Part A: Pol. Pract. 132, 97–109.

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.

Jensen, A.F., Cherchi, E., Mabit, S.L., 2013. On the stability of preferences and attitudes before and after experiencing an electric vehicle. Transport. Res. Part D: Transport Environ. 25, 24–32.

Kumar, R.R., Alok, K., 2020. Adoption of electric vehicle: a literature review and prospects for sustainability. J. Cleaner Prod. 119911.

Langbroek, J.H., Franklin, J.P., Susilo, Y.O., 2016. The effect of policy incentives on electric vehicle adoption. Energy Policy 94, 94–103.

Larson, P.D., Viáfara, J., Parsons, R.V., Elias, A., 2014. Consumer attitudes about electric cars: Pricing analysis and policy implications. Transport. Res. Part A: Pol. Pract. 69, 299–314.

Li, L., Wang, Z., Chen, L., Wang, Z., 2020. Consumer preferences for battery electric vehicles: A choice experimental survey in China. Transport. Res. Part D: Transport Environ. 78, 102185.

Schmalfuß, F., Mühl, K., Krems, J.F., 2017. Direct experience with battery electric vehicles (BEVs) matters when evaluating vehicle attributes, attitude and purchase intention. Transport. Res. Part F: Traffic Psychol. Behav. 46, 47–69.

Scorrano, M., Danielis, R., Giansoldati, M., 2019. The Cost Gap Between Electric and Petrol Cars. An Estimate via a Persona-Based Deterministic and Probabilistic Total Cost of Ownership Model. Int. J. Transport Econ. XLVI/3, 93–122.

Scorrano, M., Danielis, R., Giansoldati, M., 2020b. Dissecting the total cost of ownership of fully electric cars in Italy: The impact of annual distance travelled, home charging and urban driving. Res. Transport. Econ. 100799.

Train, K.E., 2009. Discrete choice methods with simulation. Cambridge University Press.

Valeri, E., Cherchi, E., 2016. Does habitual behavior affect the choice of alternative fuel vehicles? Int. J. Sustain. Transport. 10 (9), 825–835.

Valeri, E., Danielis, R., 2015. Simulating the market penetration of cars with alternative fuelpowertrain technologies in Italy. Transp. Policy 37, 44–56

Copyrights