Does electric car knowledge influence car choice? Evidence from a hybrid choice model

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ABSTRACT

We present the results of a stated preference study undertaken in Italy in 2017 on individuals' preferences between an electric car (EC) and a petrol car, with the purpose of assessing the impact of the latent variable EC knowledge on purchasing decisions. We estimate a multinomial, a mixed and two hybrid mixed logit models, with the interaction between EC knowledge, car attributes and additional exogenous covariates. We use three measurement equations to estimate the self-assessed car knowledge, assessed EC knowledge and EC driving experience. We report three main findings. First, the inclusion of EC knowledge improves our capability to explain car choice. Second, the degree of EC knowledge does not change the negative perception respondents have, *ceteris paribus*, on ECs. Third, the level of EC knowledge influences the importance placed on the attributes of the choice model. Specifically, a higher level of EC knowledge is associated with a lower concern with fast charging station density. Our results are useful for car manufacturers who wish to improve their marketing strategies through tailored advertising efforts, and for policy makers who wish to implement educational campaigns as a means to foster EC uptake.

1. Introduction

The choice of an EC stems from a cognitive and emotional relationship between the potential buyer and the car. Such a relationship emerges from the interaction amongst a series of factors, including the marketing policies of car manufacturers, clients' interest and cognitive effort, and the informational campaigns on sustainable mobility enacted by the policy makers at both the national and local level. Car manufacturers actively promote their cars and inform customers through advertising campaigns, dealers, or specific programs aimed at educating consumers on the technical and functional characteristics of their endothermic vehicles. Beyond their informational value, these campaigns build consumers' loyalty and differentiate products by highlighting their innovative content.

In the transportation economics literature, hybrid choice models (HCMs) help explore the role of attitudes and perceptions in transport decisions. A pioneering contribution is provided by Daziano and Bolduc (2013), who study how Canadian consumers' choice among four alternative powertrain technologies is affected by a latent variable aimed at capturing environmental awareness. Their empirical results confirm that environmental-conscious consumers are willing to pay more for low-emission vehicles. A similar outcome is found by Jensen, Cherchi, and Mabit (2013), who analyze how the individual attitudes towards the environment shape the choice between an electric and a conventional car, before and after a three-month real driving experience with an electric vehicle (EV). The importance of latent variables is confirmed by Kim, Rasouli, and Timmermans (2014), who study consumers' intention to buy an EC accounting for the role of five latent variables: environmental beliefs toward ECs, economic aspects, battery aspects, perception on the ECs' technological stage of development, and innovation value. Some years later, Kim, Rasouli, and Timmermans (2016) study the impact on car buying intentions of environmental, battery and innovation-related perceptions. Glerum, Stankovikj, Thémans, and Bierlaire (2014) analyze how a pro-leasing and a pro-convenience attitude influence individual preferences. Valeri and Cherchi (2016) investigate the role of habits, measured by the frequency of car trips per week, car as a main transport mode, and a self-assessed car knowledge. Cherchi (2017) focuses on the impact of both informational and normative conformity in users' choices. Soto, Cantillo, and Arellana (2018a) analyze how environmental concern, pro-technology attitudes and pro-car use attitudes influence car choice. Krause, Carley, Lane, and Graham (2013) analyze the effect of misunderstandings or

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misperceptions about selected EC characteristics, using however an OLS model instead of an HCM.

Taking advantage of an exploratory stated choice survey carried out in 2017 in an Italian region, the Friuli Venezia Giulia Region, this paper adds to the literature by specifically focusing on the role of EC knowledge in determining car choice. Our assumption is that, since ECs are a new product, subject to high uncertainty, the level of knowledge of ECs might play an important role. In fact, ECs are subject to technological (e.g., car performance in different traffic conditions, battery degradation, battery charging, range limitations), economic (e.g., residual value, energy efficiency) and political (e.g., EC and infrastructure incentives and regulation connected with their environmental properties) uncertainty, which could, to some extent, be reduced by proper information. The latent variable EC knowledge is measured in this paper through three indicators, i.e. self-assessed car knowledge, "objective" (assessed) EC knowledge, and EC driving experience. At the time of the survey, in Italy the general level of EC knowledge was probably low, since Italy was still in the early days of EC uptake. In the following years, various government policies (purchase subsidies, free parking and unconstrained access to limited traffic zones) enhanced the level of EC penetration and several traditional and social media discussed with more detail and precision the ECs' pros and cons.

The findings of the paper, although based on an admittedly limited sample (N = 200), could be useful at least for three reasons. First, they shed light on the relationship between EC knowledge and purchase choice. Second, they help car manufacturers in defining their marketing strategies eventually enhancing their informational content. Third, they provide suggestions to policy makers to use educational campaigns as a tool to foster EC uptake.

The remainder of the paper is organized as follows. Section 2 describes the stated choice experiment and the data collection process, providing descriptive statistics of the sample. Section 3 illustrates the modelling framework and Section 4 discusses the results. Section 5 concludes, highlights shortcomings of the study, and provides indications for future research.

2. Stated choice experiment and descriptive statistics

The hybrid mixed logit model is estimated with data deriving from interviews administered in 2017 in the Friuli Venezia Giulia Region, located in the Northeast of Italy.

The interviews are made up of a questionnaire divided into two sections. In the first section we asked the respondent to supply socioeconomic information, including: 1) personal data; 2) car and garage ownership; 3) mobility habits; 4) car knowledge and attitude towards ECs. In the second section we propose to respondents 10 choice scenarios as illustrated in Fig. 1. Based on Coffman et al. (2017) and Liao, Molin, and van Wee (2017) we characterize each scenario using as attributes brand, purchase price (€), annual operating cost (gasoline, insurance, tax, maintenance) (€), driving range (km), and the percentage of fuel service stations endowed with fast electric charging capability. This choice obviously disregards many other choice determinants discussed in the literature, such as charging times and costs, safety, with specific reference to the risk of fire deriving from a large battery, ambiguity on expenses required to install a wall box at home, especially for individuals who live in a condo with shared parking facilities, uncertainty on the environmental effects stemming from the use of an EC and of battery disposal, resale value, availability of capable repair assistance and uncertainty on their costs, just to name a few.

Therefore the impact of these omitted variables will be captured in the alternative specific constant and in the latent variables.

Each scenario is characterized by two car models chosen from the 4 best-selling EC and their petrol equivalent in the Italian market. The ECs are the VW E-Golf equipped with a 35.8 kWh battery, the Renault Zoe, the Nissan Leaf and the Daimler Smart forfour EQ, whilst the petrol car are the VW Golf, the Renault Clio, the Nissan Pulsar and the Daimler Smart forfour. The Status Quo (SQ) attribute levels for each car are set equal to the Italian average values as reported in Table 1. They are varied as follows: i) four brands; ii) purchase price: -20%, SQ, +20%, +40%; iii) driving range: SQ, +20%, +40%; iv) annual operating cost: -20%, SQ, +20%; v) the percentage of fuel service stations equipped with fast electric charging capability: SQ, +30%, +50%. The SQ for the annual operating costs attribute are based on Danielis, Giansoldati, and Rotaris (2018). We used an efficient experimental design strategy in two different waves with the aim of minimizing the asymptotic standard error (Bliemer & Rose, 2010, 2011; Huber & Zwerina, 1996; Yu, Goos, & Vandebroek, 2009).

We use three survey channels: Google-Forms (110 valid responses), 22 face-to-face interviews, and 68 collective paper-and-pencil interviews, for a total of 200 valid interviews. We test whether the results are dependent on the channel used, finding no statistical difference.[1] As suggested by an anonymous reviewer, potential self-selection might have occurred especially in the first channel we used to collect the data.

The sample of individuals we analyze is quite heterogeneous. Its features are summarized in Table 2.

Two thirds of the respondents live in urban areas and most of them own a garage. Car knowledge is measured through a self-assessment via a Likert scale that ranges from 1, i.e. none, to 7, i.e. very high. More than 40% of the respondents declare to have a quite good knowledge of cars in general. As far as EC knowledge is concerned, half of respondents have a good knowledge, since they provided a correct answer to questions about ECs' range and charging time. Yet, only 18% had a direct driving experience. Compared to our sample, the actual population of Friuli Venezia Giulia is less educated, with a mere 15% holding a graduate or a postgraduate degree (year 2018), is less wealthy, with circa 98% earning no more than 75,000 Euros per year (year 2017), and is much older, with 36% of inhabitants aged 61 or more (year 2017).

3. Modelling framework

Following Soto, Márquez, and Macea (2018b, pp. 70–72), the individual-specific latent attribute car knowledge (η) is described by the structural equation (1). It contains the individual socioeconomic features (S_q), where q refers to the respondents, i to the propulsion system and r to an explanatory variable. α are parameters to be estimated, whilst υ_{iq} are error terms with zero mean.

$$\eta_{iq} = \sum_r \alpha_{ri} S_{riq} + \upsilon_{iq} \tag{1}$$

We modelled the measurement equation as an ordered logit model, where each discrete choice response k is obtained from the individual-specific latent attribute plus an error term via a censoring mechanism that identifies different categories of response. The categorical response in the indicator Z_{iq} is defined as a set of thresholds parameters (τ) to be estimated.

$$Z_{iq} = \begin{cases} 1 \ if \ (-\infty) < Z^*_{iq} \le \tau_1 \\ 2 \ if \ \tau_1 < Z^*_{iq} \le \tau_2 \\ 3 \ if \ \tau_2 < Z^*_{iq} \le \tau_3 \\ \cdots \\ K \ if \ \tau_{K-1} < Z^*_{iq} \le \infty \end{cases} \tag{2}$$

[1] In order to control for possible different outcomes stemming from the data collection method, we included in our preferred estimations a categorical variable that takes the values of 1, 2, and 3 if the survey was administered via Google-Forms, face-to-face, and paper-and-pencil interviews, respectively. Results not reported here for the sake of brevity show that the collection method has no significant impact on the estimated coefficients.

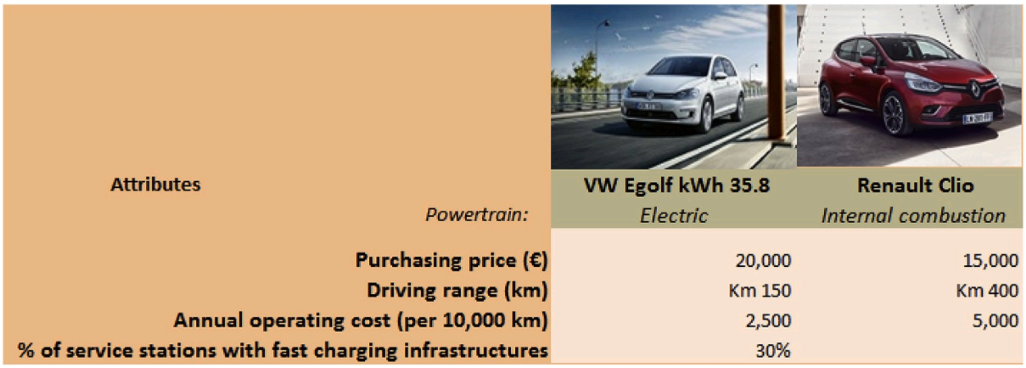

Fig. 1. Example of state preference choice proposed to the respondent.

Table 1
Status quo for the main attributes of the eight selected cars.

Attributes	Daimler Smart forfour EQ	VW Golf	VW Egolf kWh 35.8	Renault Clio	Renault Zoe	Nissan Pulsar	Nissan Leaf	Daimler Smart forfour
Purchase price (€)	24,559	20,400	37,600	16,350	33,250	18,090	30,690	12,960
Driving range (km)	145	610	300	714	300	1000	199	428
Annual operating cost (€)	1791	3396	1666	2908	1679	2859	1750	3049

Table 2
Summary statistics of the sample.

Socio-economic information			
Gender		*Current employment*	
• Males	52.0%	• Employee	41.5%
• Females	48.0%	• Managerial employee	7.5%
Age		• Entrepreneur	10.5%
• From 18 to 30	43.5%	• Student	24.5%
• From 31 to 60	54.0%	• Working-student	3.5%
• More than 60	2.5%	• Retiree	2.0%
Level of education		• Housewife	3.5%
• Middle school	4.0%	• Unemployed	0.5%
• High school diploma	41.0%	• Other	6.5%
• Undergraduate degree	48.5%	*No. of owned cars in the family*	
• Postgraduate degree	6.5%	• 0 cars	0.5%
Net yearly household income		• 1 car	18.5%
• Less than €30,000	30.5%	• 2 cars	51.5%
• Between €30,000 and €70,000	49%	• 3 cars	19.5%
• More than €70,000	20.5%	• 4 cars	7.5%
Place of residency		• 5 cars	2.5%
• Urban	68%	*Availability of a garage or car box*	
• Non-urban	32%	• Yes	83%
		• No	17%
Self-assessed car knowledge		**Attitude towards EC**	
Reply to the following question "How much do you know about cars?" Likert scale from a minimum of 1 (no knowledge) to a maximum of 7 (car expert)		*ECs' knowledge (our elaboration on respondents' knowledge on ECs' driving range and minimum time required for a full charge)*	
• Reply 1	10.5%	• Scarce	55.5%
• Reply 2	9.5%	• Good	44.5%
• Reply 3	19%		
• Reply 4	20%	**ECs' driving experience**	
• Reply 5	25.5%	• Yes	13%
• Reply 6	12%	• No	86.5%
• Reply 7	3.5%	• Missing	0.5%

$$Z^*_{iq} = \gamma_i \eta_{iq} + \zeta_{iq} \tag{3}$$

Equation (4) provides the utility function of the HCM. Asc_i is the alternative-specific constant, which, in our case, captures the effect of the electric propulsion system, *ceteris paribus*, whilst we need to estimate the parameters θ, β, and φ, which are associated with the design attributes X_q and the individual-specific latent attribute η_q.

$$U_{iq} = Asc_i + \sum_g \theta_{gi} X_{giq} + \beta_i \eta_{iq} + \sum \varphi_{gi} X_{iq} \eta_{iq} + \varepsilon_{iq} \tag{4}$$

Assuming that the error term ε_{iq} is i.i.d., then the differences between the utilities of the alternatives follow a logistic distribution, leading to the well-known multinomial logit model (MNL).

Table 3 shows in the first part the metrics used to describe the attributes of the hypothetical alternatives – which embrace both dichotomous and continuous variables – in the second part the socio-economic characteristics – which enter the model as dummy variables – and in the third part the metrics employed to measure the latent variable, *EC knowledge,* which is itself described by three variables and an equal number of measurement equations. The measurement indicator of the variable representing the respondents' self-assessed level of car

Table 3
Variables used in the model.

Group	Variable	Type	Description
Design attributes	*Volkswagen brand/model*	Dummy	1: car branded VW; 0: otherwise
	Renault brand/model	Dummy	1: car branded Renault; 0: otherwise
	Nissan brand/model	Dummy	1: car branded Nissan; 0: otherwise
	Purchase price	Continuous	€1000
	EC Range	Continuous	Km 100
	Non-EC Range	Continuous	Km 100
	Annual operating costs	Continuous	€1000
	% of fuel stations with fast charging stalls	Bounded	Percentage
Socio-economic characteristics	*Gender*	Dummy	1: female; 0: male
	Employed	Dummy	1: employed; 0: other
	Garage	Dummy	1: garage owned; 0: other
Measurement indicators	*Self-assessed car knowledge*	Ordinal (1–7)	1: lowest; 7: highest
	Assessed EC knowledge	Ordinal (0–1)	0: assessed; 1: not assessed
	EC driving experience	Ordinal (0–1)	0: driven; 1: not driven

knowledge, (*Self-assessed car knowledge*), ranges from a minimum of 1, which indicates the total absence of knowledge, to a maximum of 7, which instead indicates an individuals' perception to be a car expert. The measurement indicator of the variable "objective" knowledge, (*Assessed EC knowledge*), is defined on the basis of the respondent replies to two questions, i.e. 1) "Which is the maximum driving range of an EC?" and 2) "What do you think is the minimum time required to charge an EV?" The replies were classified as correct or incorrect considering whether they were reasonable based on the prevailing technological condition at the time of the interview. In order to classify for EC knowledge both replies had to be correct. The measurement indicator takes the value of 0 if the respondent provided a correct reply, and 1 otherwise.[2] The measurement indicator of the variable describing the respondents' previous EC driving experience, (*EC driving experience*), ranges from 0, which indicates that the respondent has at least once driven an EC, to 1, which indicates that the respondent has never driven one.

Fig. 2 shows the final structure of the HCM, i.e. the one with the largest set of significant parameters and the highest explanatory power. We tested several covariates including the purchase price, driving range, annual operating costs, density of charging stations with fast charging, plus a series of characteristics associated with the household, i.e., age, gender, level of education, current employment, net yearly income, place of residency, number of cars owned in the family, availability of a garage, number of yearly return trips by car over 400 km, EC's knowledge, driving experience and purchase intentions.

4. Results

We estimate four discrete choice models (Table 4). We start with a simple binary choice model (although we will use the more general term, MNL) to evaluate how the vehicle attributes and the fast charging network density impact respondents' utility. All attributes have the expected sign. The alternative specific constant EC (*ASC_EC*) is statistically significant and reveals that respondents' utility decreases if the car is electric-powered, meaning that, *ceteris paribus,* attributes other than those specified in the model negatively affect the utility that respondents derive from an EC. They are most likely associated with psychological barriers, technological mistrust, charging constraints and safety concerns. Concerning the financial costs, the *Purchase price* is 95% significant, whereas the *Annual operating costs* is only 90% significant. Such a difference (confirmed across model specifications) signals a greater attention to the higher immediate lump sum cost associated with the purchase of an EC relative to a non-EC than to the relative savings in term of operating cost during the ownership period. With reference to the driving range, the *Non-EC range* coefficient is much lower than that of the *EC-range*, in line with previous findings by Giansoldati, Danielis, Rotaris, and Scorrano (2018) and Valeri and Danielis (2015). We also find a strong brand\model effect. Respondents, in fact, significantly prefer the Volkswagen Golf and to a lesser extent the Renault Zoe relative to the omitted Daimler Smart forfour. They are indifferent between the Nissan Leaf and the Daimler Smart forfour, regardless of their different size. Motivations connected with esthetics and use (the Smart forfour is a very successful car in Italy due to its size that fits well in the narrow streets of the Italian cities) are likely to explain this result.

Next, we allow for randomly-distributed parameters in order to capture preference heterogeneity among individuals. We tested several specification and report the one with the best fit. Two variables, *ASC_EC* and *Purchase price*, exhibit a significant heterogeneity level. Overall, the goodness of fit of the model improves: the log-likelihood (LL) values at convergence increase from −1315 to −1259 and both the AIC and BIC statistics decrease.

The third and fourth model specifications incorporate the latent variable EC knowledge: the hybrid mixed logit (HMXL) model accounts only for the latent variable, while the fourth model (HMXL with interactions) estimates the interaction between the latent variable and the variables representing the *ASC_EC*, the *Volkswagen brand/model* and the *% of fuel stations with fast charging stalls*. This latter specification results from several tests on alternative specifications. Because of their entirely new set of parameters, the hybrid models are not directly comparable with the former two models. What is decisive is the log-likelihood of the choice model only (see Walker & Ben-Akiva, 2002 and Schmid & Axhausen, 2019 for details). Table 4 shows that the LL (choice) value drops to −1256 and to −1240, respectively. The implication is that the introduction of the latent variable *EC Knowledge* improves the ability of the model to explain respondents' choice. The improvement is higher when the latent variable is interacted not only with the *ASC_EC* but also with the variables *Volkswagen brand/model* and *% of fuel stations with fast charging stalls*.

More in detail, the positive parameter associated with the *LV* * *ASC_EC* variable in the HMXL model indicates that a higher *EC knowledge* reduces the aversion towards ECs. In fact, the *ASC_EC per se* reduces utility by 1.036, a value that is partly offset by the LV component equal to 0.102. This point illustrates the ability of a hybrid model to disentangle heterogeneity. The HMXL with interactions further clarifies that *EC knowledge* significantly strengthens the preference for the *Volkswagen brand\model* versus the Daimler Smart forfour and reduces the sensitivity to the *% of fuel stations with fast charging stalls*. The structural model indicates that gender and occupation are related with the LV *EC knowledge*: EC knowledge is higher with employed men. As to the measurement model, the three indicators (*Self-assessed car knowledge, EC driving experience,* and *Assessed EC knowledge)* are positively correlated to the LV *EC knowledge*. Almost all thresholds of the ordered logit model related to self-assessed level of knowledge are statistically significant, signaling that they are correlated with EC knowledge. A similar result holds for the *EC driving experience* indicator. On the contrary, the measurement indicator *Assessed EC knowledge* is not statistically significant, meaning that the questions we used to assess EC knowledge suffer from uncertainty.

To the best of our knowledge, no publication has so far explicitly analyzed the determinants of EC knowledge, despite a recent attempt provided by Anfinsen, Lagesen, and Ryghaug (2019) for Norway. They explore the role played by gender in the emerging culture of EVs and show that despite both women and men see the driving experience as a learning process, men are sometimes considered driving more and thus more competent EV drivers.[3] Again for Norway, Sovacool, Kester, Noel, and de Rubens (2019) find that men reported greater usage rates for cars and EVs than women, proving that the allegedly masculine preference for conventional cars is fading. On the contrary, the relationship between gender and car knowledge has been investigated by Polk (2004), Simićević, Milosavljević, and Djoric (2016), Guerra, Caudillo, Goytia, Quiros, and Rodriguez (2018), and Tilley and Houston (2016) finding that men tend, in some countries, to use cars more than women, thus gaining more knowledge, although Tilley and Houston (2016) provide evidence of opposite trends in the UK. Further, we find that employed individuals are more likely to have car knowledge than unemployed respondents. It is plausible that respondents who have a job, *ceteris paribus*, are more likely to rely on a means of transportation to go to

[2] In a similar fashion, Simsekoglu et al. (2018, p. 72) measure Norwegian level of EC knowledge on the basis of the replies provided to a set of 11 questions on technical aspects about electric cars.

[3] Despite not directly connected with the association between EC knowledge and gender, it is worth recalling here the work by Krause et al. (2013) who show, amongst a set of socio-demographic features, that respondents who are male, express a higher stated intent to purchase a battery electric vehicle. In a similar fashion Kim et al. (2014) report that males tend to be more interest in the latest technological than females, and show a higher preference to purchase ECs than females do.

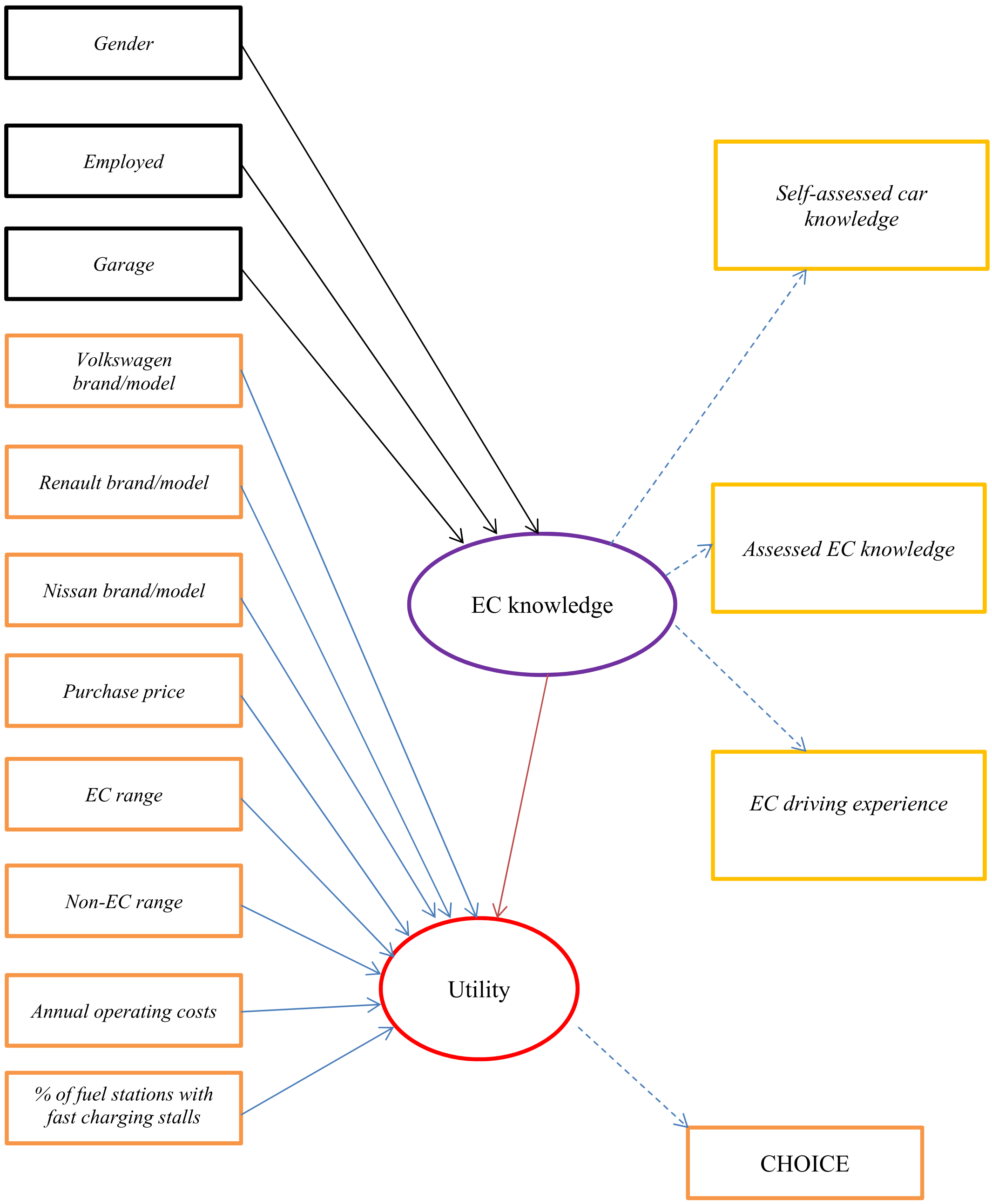

Fig. 2. Structure of the hybrid discrete choice model.

work. Finally, our model indicates that owning a garage is not statistically significant associated with the level of car knowledge. This association has not been presented before in the literature with the exception of Patt, Aplyn, Weyrich, and van Vliet (2019).

For each of the four models we have derived the implied willingness to pay (WTP) evaluation (Table 5), estimating both the value and the standard error. Following Schmid and Axhausen (2019), we present the results for the median respondent that is robust to extreme outliers. The *ceteris paribus* aversion to EC appears to be extremely high among Italian respondents. It varies across specifications ranging from €13,423 to €19, 793. The WTP estimate decreases when *EC knowledge* is introduced in the model, signaling that information about EC reduces EC aversion. As discussed above, the negative perception associated with ECs is due to economic (e.g., residual value), technological (e.g., battery degradation), safety (e.g., battery fires), and charging (e.g., long charging time) issues, often debated in the Italian media.[4] Confirming our previous studies (Giansoldati et al., 2018; Valeri & Danielis, 2015), an extra driving range km is valued €59, much more than the non-EC one (€14.6). A very high premium emerges for the *Volkswagen brand/model*, whereas the estimate for the Nissan and Renault brand/models is not statistically significant. A 1% increase in the number of fast charging stations is associated with a WTP ranging from €282 to €439, the lower value resulting from the HMXL model with an explicit interaction with the variable *% of fuel stations with fast charging stalls*.

[4] https://it.businessinsider.com/lozza-polimi-la-mobilita-verde-e-tutta-in-salita-i-diesel-di-ultima-generazione-inquinano-meno-dei-veicoli-elettrici/, last accessed on December 23rd, 2019.

Table 4
Estimates of the four discrete choice models.

Attributes	MNL		MXL		HMXL		HMXL with interactions	
	Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.	Coefficient	Std. err.
ASC_EC	−0.926***	0.252	−1.091***	0.283	−1.036***	0.287	−0.974**	0.319
Purchase price (€1000)	−0.047**	0.015	−0.058***	0.017	−0.058***	0.017	−0.054**	0.018
EC range (100 km)	0.277**	0.093	0.33**	0.101	0.330**	0.102	0.323**	0.109
Non-EC range (100 km)	0.069***	0.018	0.081***	0.02	0.081***	0.02	0.079***	0.022
Annual operating cost (€1000)	−0.124*	0.068	−0.146**	0.074	−0.148**	0.074	−0.146*	0.080
Volkswagen brand/model	0.76***	0.113	0.908***	0.125	0.909***	0.125	1.039***	0.163
Nissan brand/model	0.147	0.139	0.171	0.151	0.17	0.151	0.204	0.165
Renault brand/model	0.165*	0.099	0.196*	0.108	0.196*	0.108	0.213*	0.118
% of fuel stations with fast charging stalls	0.021***	0.003	0.024***	0.004	0.024***	0.004	0.022***	0.005
Standard deviations of normally distributed parameters								
sigma_ASC_EC			0.913***	0.091	−0.876***	0.099	0.926***	0.094
sigma_Purchase price			0.045**	0.019	0.042**	0.021	0.04*	0.022
sigma_EC range			0.004	0.118	−0.015	0.117	−0.009	0.112
sigma_% of fuel stations with fast charging stalls			0.00	0.012	−0.006	0.009	0.001	0.011
Estimated parameters of the structural model								
LV_Gender (female = 1)					−3.451**	1.372	−2.457***	0.512
LV_Employed (being employed = 1)					1.335**	0.631	1.118***	0.333
LV_Garage (available = 1)					0.088	0.455	−0.142	0.353
Estimated parameters of the measurement model								
*LV * ASC _EC*					0.102*	0.056	0.25	0.210
*LV * Volkswagen brand/model*							0.243**	0.114
*LV * % of fuel stations with fast charging stalls*							−0.007**	0.003
zeta_Self-assessed car knowledge					0.741**	0.348	0.978***	0.218
zeta_EC driving experience					0.511**	0.252	0.767**	0.251
zeta_Assessed EC knowledge					0.327**	0.148	0.41***	0.124
tau_Self-assessed car knowledge_1					−3.407***	0.528	−3.516***	0.510
tau_Self-assessed car knowledge_2					−2.473***	0.463	−2.548***	0.452
tau_Self-assessed car knowledge_3					−1.081**	0.382	−1.136**	0.384
tau_Self-assessed car knowledge_4					0.194	0.357	0.143	0.365
tau_Self-assessed car knowledge_5					2.017***	0.425	2.032***	0.417
tau_Self-assessed carknowledge_6					3.867***	0.589	3.94***	0.565
tau_EC driving experience					1.944***	0.341	2.016***	0.380
tau_Assessed EC knowledge					0.06	0.207	0.048	0.205
Model Diagnostics								
n (observations)	2000		2000		2000		2000	
k (parameters)	9		13		28		36	
Draws			1000		1000		1000	
LL (start)	−1386		−1386		−1979		−1979	
LL (final)	−1315		−1259		−1780		−1765	
LL (choice)	−1315		−1259		−1256		−1240	
AIC	2648		2544		3616		3603	
BIC	2699		2617		3773		3805	

Notes: ***, **, * indicate significance at the 1%, 5%, 10% respectively.

Table 5
Median WTP valuation (values in Euros).

	MNL	MXL	HMXL	HMXL with interactions
ASC_EC	−19,793***	−18,862***	−16,065**	−13,432*
EC range	59.08***	57.08***	56.82***	56.22**
Non-EC range	14.65***	13.99***	13.95***	12.42**
Volkswagen brand/ model	16,251***	15,694***	15,641***	23,802**
Nissan brand/ model	3134	2948	2927	4798
Renault brand/model	3522*	3385*	3364*	4330
% of fuel stations with fast charging stalls	439***	420***	418***	282**

Notes: ***, **, * indicate significance at the 1%, 5%, 10% respectively.

5. Conclusions

The paper illustrates a stated preference study undertaken in Italy in 2017 on individuals' preferences between an EC and a petrol car. The aim is to evaluate the impact of EC knowledge on purchasing decisions. We estimate a MNL, a MXL and two HMXL models. The three main findings are the following. First, incorporating EC knowledge in the model greatly enhances our ability to explain car choice. Second, EC knowledge offsets but does not radically alter the negative attitude towards ECs, *ceteris paribus*, as captured in the ASC of the estimated models. Third, EC knowledge seems to affect the importance placed on the attributes of the choice model that we have used to characterize our choice scenario. In the hybrid model specification, the respondents with higher EC knowledge place less relevance to the fast charging station density and have a stronger preference for the Volkswagen Golf vs the Daimler Smart forfour.

Our findings suggest that as EC penetration progresses (in Italy as around the world), the increased EC knowledge will alter consumers' preferences, probably reducing the misunderstandings or misperceptions underlined by Krause et al. (2013). One of the most important obstacles towards EC acceptance has certainly been the EC driving range and the existence of an underdeveloped charging infrastructure. Our results suggest that the negative influence exerted by these factors on car choice is likely to reduce over time as EC knowledge, including EC direct and indirect experience, improves.

Many obstacles, however, still exist and their impact has not yet been fully evaluated, including charging times and costs, fire safety, charging issues especially for individuals without a private parking facility, battery disposal, resale value, and so on. Consequently, we deem important that all stakeholders playing a role in spreading information on ECs (researchers, OEMs, policy makers, internet influencers, such as blogger or You-tubers) continue on providing in-depth and reliable evidence on the EC properties.

CRediT authorship contribution statement

Marco Giansoldati: Writing - original draft, Data curation, Writing - review & editing. **Lucia Rotaris:** Formal analysis, Software, Writing - review & editing. **Mariangela Scorrano:** Software, Writing - review & editing. **Romeo Danielis:** Conceptualization, Methodology, Supervision, Writing - original draft.

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