Drivers' preferences for electric cars in Italy. Evidence from a country with limited but growing electric car uptake

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A B S T R A C T

So far, Italy has shown a much lower electric vehicle (EV) adoption rate than other European countries. In an effort to understand the motivations for the limited but growing EV uptake, this paper focuses on Italian drivers' preferences resulting from a stated preference survey carried out in October-December 2018. 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). The econometric analysis of the stated choices confirms that the vehicle attributes such as purchase price, fuel economy, and driving range play a very relevant role. The time spent to charge the vehicle affects negatively the respondents' utility, while the fast charging network density is not yet perceived as significant or carries a counter-intuitive sign. On the contrary, the possibility to park EVs for free, even for a limited time, in the city central areas is positively valued by the respondents. Comparing our estimates with previous Italian studies, in particular with Giansoldati et al. (2018) who uses a similar questionnaire but on an earlier and more limited sample, there are hints of a change in the perception of the Italian drivers towards EVs. A noticeable difference is the value of the EV alternative specific constant. Giansoldati et al. (2018) find a negative value while this study finds a positive one. A second finding is that the willingness to pay for an additional driving range kilometre is lower than that previously found, indicating that Italian drivers are becoming more confident on EV driving range. Scenario analysis indicates that in Italy financial incentives would have a larger impact on the probability of buying an EV than technological improvements.

1. Introduction

European countries are characterized by different levels of electric vehicles (EV[1]) uptake. In 2018, the absolute forerunner was certainly Norway with 32.9% new passenger car registrations[2], 20.9% of which are battery-only vehicles (BEVs) and 12% plug-in electric vehicles (PHEVs) (ACEA, 2019). Other Nordic countries follow suit, with Sweden having in 2018 a percentage of EVs registrations equal to 7.4%, the Netherlands 6.3%, and Finland 4.5%. Other large European countries with a strong car

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[1] Throughout the paper we will use the widely used acronym EV (electric vehicles), although our paper deals exclusively with cars. In particular, the stated choice experiment presented below deals with battery-only electric cars. For the international comparison we use the 2018 European Automobile Manufacturers' Association (ACEA) data since the 2019 official data are not yet available.

[2] Some sources report higher values for Norway because they include also imported vehicles.

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manufacturing tradition such as Germany, France and the UK have EV market shares equal to 1.9%, 2.1% and 2.5%, respectively. Italy is lagging behind: in 2018, the EV registrations were only 0.5%, 0.3% of which BEVs and 0.2% PHEVs. Italy's EV penetration level is similar to that of Bulgaria, Latvia, Romania, and slightly higher than that of Lithuania, Czech Republic, Estonia, Greece, Slovakia and Poland. Portugal has a remarkably high share of EVs (3.3%), and Spain 0.9% (ACEA, 2019). In parallel with the low EV uptake, Southern and Eastern European countries are poorly researched. Kumar and Alok (2020), in a recent survey, document that out of the 239 selected research papers on EV adoption, less than 5 focus on Southern and Eastern European countries.

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 PM_{10}, $PM_{2.5}$, O_3, and NO_2 concentration levels well-above the air quality standards set by the European directives.

One of the main characteristic of the Italian car fleet is the high proportion of small and medium sized cars. In fact, in 2019 the A and B car segments accounted for 16.9% and 34.9% of the total new car sales, respectively. In these segments, the only available BEVs were the Daimler Smart (fortwo and forfour) and the Renault Zoe, which were thus the two best-selling BEVs, with 2359 and 2180 units, respectively. Segment C (which includes models such as the Nissan Leaf and the VW e-Golf) amounted to 33.6% of the market. The remaining 15% sales took place in the D, F, and G segments, where prestigious brands such as Tesla, Audi and Jaguar offered high-end BEV models. Remarkably, FCA (former FIAT) did not offer in Italy the FIAT 500e (on sale in California only), and the company's reluctance to invest in BEVs and to develop a compelling model for the Italian market certainly heavily contributed to the limited Italian BEV uptake. Starting from summer 2020, electric versions of the Fiat 500 or of the FIAT Panda are expected to be commercialized.

Another important characteristic of the Italian car market is the reliance on diesel cars, manufactured also for the segment B (e.g., Fiat 500X). Thanks to their limited fuel consumption and to the favourable diesel fuel taxation, the market share of diesel cars has been in Italy traditionally high and the total cost of ownership of both the petrol and the diesel cars has been largely lower than that of their BEV equivalents (Giansoldati et al., 2018; Scorrano et al., 2019, 2020a). The advantageous fiscal treatment extended also to the vehicles, since in Italy, compared to Norway for instance, the registration taxes levied on conventional cars are rather low (Scorrano et al. 2020b). Consequently, in Italy the initial cost barrier associated with BEV is quite high. EVs cost almost twice as much as their equivalent conventional cars, making them an unlikely choice for the Italian drivers. In addition, the economic recession and the slow recovery of the Italian economy of the last decade reduced the purchasing power of a large section of the population, which in turn slowed down the rate of car renewal.

Only recently, starting from April 2019, the Italian government enacted a €4000–6000 subsidy for BEVs, reducing partly the initial cost gap between conventional and electric cars. Moreover, some Regions and Municipalities helped improving BEV competitiveness by providing further purchasing subsidies or favourable access conditions and reduced parking fees in the city centers.

The slow BEV uptake went in parallel with the slow diffusion of the charging infrastructure in a likely bidirectional causal relationship. Even if, with the help of European funds in 2019, the charging network in Italy is becoming denser, compared with the Northern and Central European countries, it is still lagging behind, with a noticeable lack of fast charging stations. The main public charging station provider is ENEL X, a branch of the former electricity state monopolist ENEL. The main tolled highway Italian operator, Autostrade per l'Italia, opposed the construction of fast chargers in the areas occupied by the petrol stations so that ENEL X could install its network only outside the highways. In addition, even the coverage of the Tesla superchargers is limited and located mostly in the richer Northern Regions, while the Ionity network is still in the initial phase (with 2 stations only, as of December 2019).

As a result of the low uptake, the level of EV knowledge of the Italian drivers is still low, based more on the information circulating in the social media than on direct experience. Furthermore, unlike in Germany and Austria, in Italy the Green party has never played a significant political role, possibly testifying a reduced importance attributed by Italian voters to environmental issues.

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.

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.

Our findings could be of value to both car manufacturers and policy makers, especially in the countries where EV uptake is still limited, like the Southern and Eastern European countries. Car manufacturers might use them to choose which EV segment to target and which pricing strategy to adopt. Policy makers might use them to forecast the effectiveness of the financial and technological policies on EV uptake.

The paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the stated choice experiment and the data collection methodology. Section 4 introduces the discrete choice modelling framework. Section 5 presents the econometric results of multinomial logit (MNL) and random parameters logit (RPL) models and compares them with previous Italian and international studies. Section 6 describes the scenario analysis, and Section 7 concludes and draws the main policy implications.

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).

Among these, the papers that analyse consumers' preferences and how these translate into consumers' choices are of special interest for the purpose of this study. A survey of 50 peer-reviewed studies published up to the year 2015 is performed by Coffman et al. (2016). They focus on the factors influencing EV adoption and distinguish among internal factors (vehicle ownership costs, driving range and charging time), external factors (fuel prices, consumer characteristics, charging networks, public visibility and social norms) and policy mechanisms (financial and non-financial incentives, supporting charging infrastructure, raising awareness). All the reviewed studies rely on surveys concerning hypothetical situations. The authors identify several knowledge gaps including mixed evidence of the effectiveness of government incentives and the direction of causality between public charging infrastructure and EV uptake. A further review study has been compiled by Liao et al. (2017). They review 26 studies published in the period 2005–2015. Again, all studies are based on stated preference data due to the still insufficient presence of EVs in the market. They identify a set of financial, technical, infrastructural and policy attributes used in the studies to construct the hypothetical scenarios. Although their analysis is purely qualitative, they are able to draw extremely interesting conclusions and propose suggestions for improvements. They find that financial, technical and infrastructural attributes are commonly found to have a significant impact on EV choice. As for the policy variables, they find that purchase incentives and tax reduction policies are effective while the impact of other policies (free parking, toll reduction, EV access to high-occupancy vehicle lanes) remains controversial. With reference to the socio-economic and demographic variables such as gender, age, income, education level and household composition, they conclude that it is unclear whether their effects are positive, negative or significant at all, since results differ among studies. They also argue that assuming stable preferences over time is inappropriate for two reasons: a) EVs became available only recently and different groups of people are going to adopt EV depending on their acceptance of innovation, and b) because EVs are still relatively new and unfamiliar to most people and in continuous development. Consequently, they claim that "people's preferences are expected to evolve along with technological progress, familiarity with EV, market penetration, social influence, etc." (Liao et al., 2017, p. 262).

In fact, regarding preferences stability over time there is conflicting evidence in the literature (de Andrés Calle et. al., 2020). Some studies detect stable preferences with respect to new products, other come to opposite conclusions. With specific reference to EVs, some studies find that preferences change over time. Jensen et al. (2014) conduct a panel survey where individuals are interviewed before and after they had experienced an EV in real life for 3 months. Using discrete choice modelling, they find that preferences and attitudes towards EVs are affected by real life experience. Carley et al. (2019) analyse via an OLS regression a longitudinal sample of more than 2000 individuals living in the 21 largest American cities. The individuals are requested in 2011 and in 2017 to state their intention to purchase or lease an EV (battery-only or plug-in hybrid electric vehicle). Although they administer a questionnaire in the same cities, only 250 respondents took the survey in both years. They find that respondents' intention to purchase or lease an EV increased between 2011 and 2017. They argue that this is due to: a) the possibility to gain experience and try them out (trialability); b) increased direct or indirect observability via social interactions, interpersonal influence and the mass media; c) network effects that rise the value of a EV as well as the number of users; and, partly, d) government EV incentivizing policies. Very recently, Jenn et al. (2020) investigate the impact of a combination of incentives on the purchase decision of EV buyers. They are able to conduct a proper cohort survey of EV owners in California every year over the period 2015–2018, finding that the importance of incentives and their effect on purchase behaviour changed over time.

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[3] 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.

Concerning Italy, to the best of our knowledge, three papers have so far investigated consumers' preferences for EVs (Table 1). In

[3] The distribution of the papers reviewed by Greene et al. (2018) per type of data is the following: 19.6% revealed preference survey, 38.6% stated preference survey, 29.3% market data and 12.5% other (including joint revealed and stated preference data).

Table 1
Recent studies on EVs in Italy (WTP values).

Authors	Valeri and Danielis (2015)	Valeri and Cherchi (2016)	Giansoldati et al. (2018)
Year of the survey	2013	2013	2017
Country	Italy	Italy	Italy
Sample size	121	121	318
Model specifications	MNL, MXL	Latent, MXL, HCM	BLM, MXL
Alternatives	6 propulsion systems	6 propulsion systems	BEV and Petrol car
Vehicle attributes	purchase price, BEV range, non-BEV range, BEV-acceleration, non-BEV acceleration, annual operating cost	purchase price, BEV range, non-BEV range, BEV-acceleration, non-BEV acceleration, annual operating cost	purchase price, BEV range, non- BEV range, annual operating cost, brand \model (VW, Renault, Nissan, Daimler)
Charging attributes	refuelling distance	refuelling distance	% of fuel station with fast charging stalls
Socio-economic attributes	gender, age, education, family income, number of family members with licence, number of trips longer than 400 km, garage ownership, car expert	education, number of family members with licence, number of trips longer than 400 km	gender, number of owned cars in the family, self-evaluated level of expertise with cars, place of residency
ASC_EV (€)	−2236	−2287	−20,167
Driving range EV (€/km)	50	42	101
Driving range petrol car (€/km)	7.5	10	14.9
Charging time (minutes)			−87 (fast charging only)
Refuelling distance		17 per km	
Free parking			1.75 (per hour)

2013 Valeri and Danielis (2015) conduct face-to-face interviews to a small sample (N = 121) of drivers asking them to state their choice among 7 alternative fuel\powertrain technologies. The hypothetical scenarios comprise 5 attributes: purchase price, annual operating cost, acceleration, driving range, and refuelling distance. Using the same sample, Valeri and Cherchi (2016) analyze how the self-evaluated level of car expertise (in general, not specifically referred to EVs) influences the choice between alternative fuel powertrain technologies. They find that respondents with a high car use, regardless of the fuel\powertrain technology, are reluctant to buy an EV. A second survey is administered in June 2017 by Giansoldati et al. (2018) to a slightly larger sample (N = 318), using a combination of direct interviews and internet-based questionnaires. They restrict their hypothetical choices to an electric and a petrol car. Their focus is on the role played by the driving range on car choice. They find an EV-specific range coefficient six times larger than that of a petrol car. The estimate varies with gender, number of cars owned by the family, and car knowledge.

Comparing the quantitative results of the three Italian studies (Table 1), one can notice that the alternative specific constant relative to the EV (ASC_EV) has a negative implied monetary value (obtained by dividing the ASC_EV coefficient by the coefficient of the purchase price), meaning that, *ceteris paribus*, Italian respondents would buy an EV only if it would cost less than a conventional one. Giansoldati et al. (2018) report an extremely high value equal to €20,167. The implied monetary value of driving range in the case of an EV varies between €42 and €101, which are very high values (a 100 km increase in the EV driving range is valued between €4100 and €10,100).

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.

Table 2 contains the descriptive statistics of the respondents. The sample is distributed among 18 of the 20 Italian regions (only Valle d'Aosta and Molise, the smallest regions, are missing). The regional representativeness is accurate at ± 10%. The sample contains slightly more men than in the Italian population (53% vs 49%). The prevailing age class is between 35 and 44 years old,

Table 2
Descriptive statistics of the sample.

Socio economic information:
- Gender: Males: 53%; Females: 47%. Coded 1,0.
- Age: From 18 to 24 years old: 10%, from 25 to 34 years old: 18%; from 35 to 44 years old: 26%; from 45 to 54 years old: 24%; from 55 to 65 years old: 22%. Coded: 18, 19 to 65.
- Level of education: elementary school or middle school: 5%; ongoing high school studies, or professional institute diploma, or high school diploma: 43%, ongoing university studies or no university degree (but high school degree earned): 8%; university diploma, or short undergraduate degree, or undergraduate degree or degree below the master level: 35%; master or specialization school or doctorate: 9%. Coded: 1 to 5.
- Current employment: entrepreneurs: 16%; director: 10%; white collar: 47%; housewife and retiree: 10%, unemployed: 8%; students: 8%; other: 1%. Coded: dummies.
- Family income: less than €30,000 per year: 48%; between €30,000 and €70,000 per year: 46%; more than €70,000 per year: 6%. Coded: 1 to 3.
- Perceived level of wealth: Question: "If you had to assess your economic condition, you would say that your family income allows you to live….". Answer: "In a wealthy fashion": 2%; "Comfortably": 45%; "With some difficulties": 40%; "with several difficulties": 10%; "I feel I am poor" 2%. Coded: 1 to 5.

Location
- By city size: more than 500 thousand inhabitants: 19%; 100–500 thousand inhabitants: 18%; 50–100 thousand inhabitants: 14%; 10–50 thousand inhabitants: 28%; less than 10 thousand inhabitants: 21%. Coded: 1 to 5.
- By region: Piemonte: 6%, Liguria: 3%, Lombardia: 17%, Trentino: 1%, Veneto: 8%, Friuli Venezia Giulia: 2%, Emilia Romagna: 6%, Toscana: 5%, Umbria: 1%, Marche: 2%, Lazio: 12%, Abruzzo: 2%, Campania: 9%, Puglia: 7%, Basilicata: 1%, Calabria: 3%, Sicilia: 10%, Sardegna: 3%.

Car and garage ownership:
- N. of owned cars in the household: 0 cars: 1%; 1 car: 37%; 2 cars: 49%; 3 cars: 10%; 4 cars: 3%; 5 cars: 0.2%; 6 cars: 0. 1%. Coded: 1 to 6.
- N. of individuals in the household who have a driving license: 1: 14%, 2: 44%, 3: 24%; 4: 14%; 5: 2%; 6: 0.2%; 8: 0.1%. Coded: 1 to 7.
- Availability of a garage: Yes: 70%; No: 30%. Coded: 1,0.

Car mobility habits:
- Average number of kilometers travelled per day: ≤ 10 km: 28%; 11–50 km: 55%; 51–100 km: 14%; > 100 km: 3%. Coded: 1 to 4.
- Average number of kilometers travelled per year: ≤ 5000 km: 24%; 5001–10,000 km: 24%; 10,001–20,000 km: 36%; 20,001–50,000: 14%; > 50,000 km: 2%. Coded: 1 to 5.
- Number of yearly return trips by car over 400 km: ≤ 10: 94%; > 10: 6%. Coded: 0,1.

Car knowledge:
- Self-evaluated level of EV knowledge (1 = None, 7 = Very high):1: 12%; 2: 18%; 3: 20%; 4: 15%; 5: 23%; 6: 7%; 7: 4%. Coded: 1 to 7.
- EVs' driving experience: Yes: 16%; No: 84%. Coded: 1,0.
- Proximity to fast charging stations: Question: "Is there a fast charging station for EV near the place where you live/work/study?" Answer: "Yes": 39%. "No": 39%. "I do not know": 22%. Coded: 1 to 3.

Attitude towards the environment:
- Environmental association: Question: "Have you ever participated to an environmental demonstration, or have you ever registered with an environmental association?" Answer: "Yes": 19%; "No": 81%. Coded: 1,0.
- Environmental concern: Question: "The environmental situation in the place where I live increasingly worries me". Answer: "Completely agree": 30%, "Quite agree": 54%, "Quite disagree": 4%: "Completely disagree": 2%. Coded: 1 to 4.

closely followed by the 45–54 and the 55–65 classes. 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.

One of the most relevant features of the sample is that 34% of the respondents claim to have a quite good knowledge of the technical characteristics of EVs (level 5 to 7), even though only 16% of them have driven them[4]. 19% of the individuals have participated to an environmental demonstration or/and have registered with an environmental association. 30% of the respondents *completely* agree with the statement that the environmental situation of the place where they live, work or study is increasingly worrisome, and 54% *quite* agree with it.

The second part of the questionnaire consisted of 12 hypothetical choice scenarios similar to the one illustrated in Fig. 1. The

[4] The exact wording of our question was: "Do you think you have a good knowledge of the technical characteristics of electric cars?" (1 = none, 7 = very high), followed by the question "Have you ever driven an electric car?". Only 16% of the respondents answer positively to the second question. Such respondents reply to the first question as follow: 1% replied 1, 9% replied 2, 11% 3, 9% 4, 37% 5, 21% 6 and the final 11% replied 7. As an anonymous reviewer commented, these variables are subjective since they are based on self-evaluations, prone to misperception or over-confidence, and not strictly comparable among respondents. Consequently, measurement errors and biased estimates are to be accounted for.

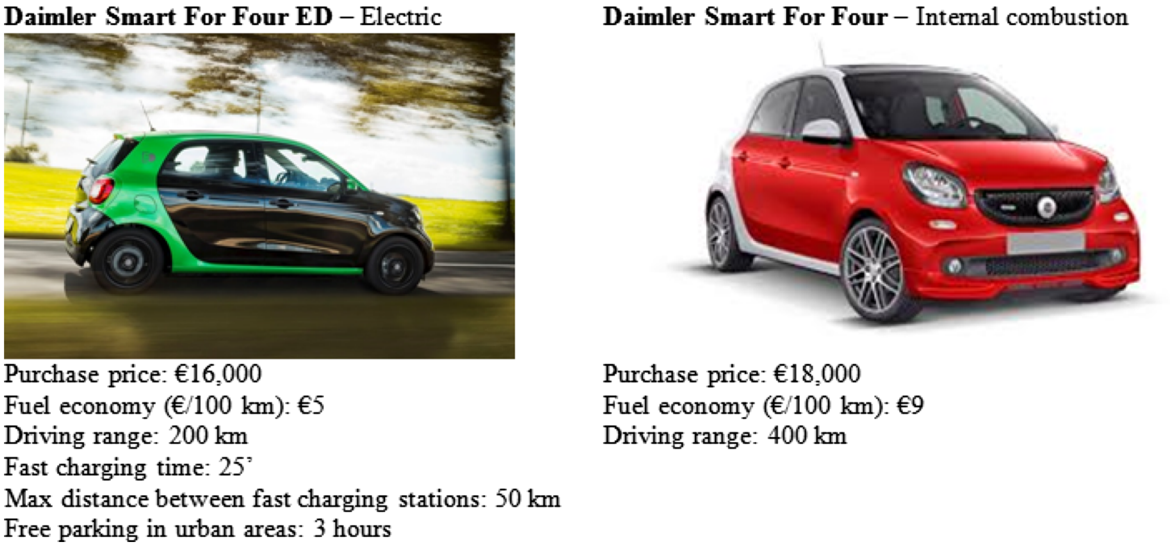

Fig. 1. Example of a stated preference choice proposed to the respondents.

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) [5].

Fuel economy is specified as cost per 100 km, differently from other studies (including Valeri and Danielis, 2015; Giansoldati et al., 2018) that use metrics such as annual fuel cost or annual operating cost (including maintenance and repairs, circulation tax, insurance premium, etc.). Such a choice has the advantage of not requiring the need to assume a given annual distance driven. However, the respondent is left with the task of performing the mental computation about how a given fuel economy impacts his\her overall total cost of ownership. Nevertheless, such a computation is required also in the real-life car choice situations. The driving range is specified in kilometres. Since each car brand\model has a specific driving range and the purchase price is correlated with the driving range, the respondent was asked to "believe" the hypothetical scenarios and to make the consequent choices.

For EVs, we assumed that the purchase price could only decrease compared to the 2018 values (Tables 3 and 4), thanks to economies of scale and technological innovation. On the contrary, for petrol cars we assumed a lower and a higher attribute level compared to the 2018 mean value. An exception was made for the BMW Series 1, whose price is already very high. As far as the driving range is concerned, we assumed that the current EV range could only improve, whilst that of petrol cars might either increase or decrease.

As far as the EV-specific attributes are concerned, we opted for the following attribute levels. Fast charging time is assumed to have three levels: 25′, 40′ and 55′. Free parking could be 1 h, 3 h, or unlimited. Relative to the maximum distance between fast

[5] At the time of preparing the survey, the five selected models comprised a large share of the available segment A and B car models (58% of the total BEV sold up to September 2018). The Tesla Model S and Model X are rated luxury cars (segment F) and the Tesla Model 3 was not yet available in Italy.

Table 3

Status Quo (SQ) for the main attributes of the ten selected cars.

	Purchase price (€)	Driving range (km)	Fuel economy (€ for 100 km)
BMW Series 1	25,250	1000	9
BMW i3	39,150	150	3
VW Golf	20,400	1000	13
VW eGolf kWh 35.8	39,600	300	3
Renault Clio	15,350	958	9
Renault Zoe	33,800	300	3
Nissan Qashqai	20,830	985	9
Nissan Leaf	33,070	300	4
Daimler Smart For Four	17,000	652	10
Daimler Smart For Four ED	24,656	120	4

Source: www.alvolante.it and our elaborations on fuel and energy prices.

Table 4

Levels of the attributes in the experiment based on the 2018 values.

Brand	Price levels for EVs (€1000)	Price levels for petrol cars (€1000)	EV driving range with full battery (100 km)	Petrol car driving range with full tank (100 km)	Fuel economy for EVs (Euro per 100 km)	Fuel economy for petrol cars (Euro per 100 km)
BMW	33; 37; 40	18; 22; 26	1.5; 2; 2.5	8; 10; 12	3; 4; 5	9; 13; 16
VW	33; 37; 40	14; 18; 22	3; 3.5; 4	8; 10; 12	3; 4; 5	9; 13; 16
Renault	24; 28; 33	10; 14; 18	3; 3.5; 4	8; 10; 12	3; 4; 5	9; 13; 16
Nissan	24; 28; 33	14; 18; 22	3; 3.5; 4	8; 10; 12	3; 4; 5	9; 13; 16
Daimler	16; 20; 24	10; 14; 18	1.5; 2; 2.5	4; 6; 8	3; 4; 5	9; 13; 16

charging stations, we assumed an optimistic level of 20 km, a realistic level of 80 km and an intermediate distance of 50 km.

Using the Ngene Software, we developed a D-efficient design of the choice tasks (Bliemer and Rose, 2011). The a-priori estimates were based on a pre-test carried out on 200 respondents in 2017 (Collavizza et al., 2017).

4. Logit model specifications

The stated choice (SC) data collected is analysed using two logit model specifications, the MNL and the RPL models which can be summarized as follows (for an in-depth presentation see Mc Fadden, 1974; Ben-Akiva and Lerman, 1985; and Train, 2009). Assuming a utility-maximizing behaviour, an individual q selects alternative j in the choice situation t from a finite set of J alternatives when that alternative yields the highest possible level of utility. We assume that the utility U_{qjt} associated with alternative j in the choice task t takes the following form:

$$U_{qjt} = \beta_j^{'} X_{qjt} + \gamma_j^{'} SE_q + \theta_j^{'} X_{qjt} SE_q + \epsilon_{qjt}$$

where X is a vector that includes all the attributes presented in the SC experiment (in our case, purchase price, fuel economy, driving range, the time required for a fast charge, the maximum distance between fast charging stations and free parking), $SE$is a vector of socioeconomic characteristics (in our case, the socio-economic variables collected in the first part of the questionnaire), and β and γ are the respective vectors of coefficients. The marginal utility of the attributes included in the SC experiment might be also interacted with the socio-economic characteristics $X_{qjt} SE_q$ being θ the vector of coefficients. ϵ is an error term varying by individual q and alternative j and choice situation t. If $\epsilon$is distributed IID extreme value type 1, the model is a standard logit model. Defining V_{qj} the systematic part of the utility function (i.e., not including the error term), the probability of an individual q choosing alternative j can be calculated simply as:

$$P_{qj} = \frac{e^{V_{qj}}}{\sum_j e^{V_{qj}}}$$

The simplicity of the model solution (closed form) comes at the price of three limitations: random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time or individuals (Train, 2009). The mixed logit obviates these limitations allowing more flexible substitution patterns. The model is reformulated as follows:

$$U_{qjt} = \beta_{qj}^{'} X_{qjt} + \gamma_j^{'} SE_q + \theta_j^{'} X_{qjt} SE_q + \epsilon_{qjt}$$

where β_q is a vector of coefficients for individual q representing that person's tastes. The coefficients vary over decision makers in the population with density $f(\beta|\Delta)$, where Δ refers collectively to the parameters of this distribution (such as the mean and covariance of given β). This specification is the same as for standard logit except that β varies over decision makers rather than being fixed. The choice probability becomes:

$$P_{qj} = \int L_{qj}(\beta) f(\beta|\Delta) d\beta$$

where $L_{qj}(\beta)$ is the logit probability evaluated at parameters β:

$$L_{qj}(\beta) = \frac{e^{V_{qj}(\beta)}}{\sum_j e^{V_{qj}(\beta)}}$$

Since the probability is not a closed form, the probabilities are approximated through simulation for any given value of Δ. It is up to the researcher to test which distribution $f(\beta|\Delta)$ best fits the data (e.g., normal, lognormal, uniform, triangular, etc.). The term "mixed logit model" refers to the presence of two distributions (for the parameters and the error term). An alternative term is random parameter logit (RPL) model, underling the fact that the preference parameters are not fixed across individuals.

While it is rather straightforward to derive the implied monetary evaluation of the attributes in the MNL model when the utility is linear in the parameters (the negative of the ratio between the attribute and the cost parameter), it is more difficult in case of systematic heterogeneity, when the utility is non-linear (Romo-Muñoz et al., 2017), or in the RPL model, since the cost parameter might be randomly distributed and include or might be close to a zero value (Hensher and Green, 2003). In this case, as suggested by Cameron and James (1987) and Cameron (1988), it is useful to re-parameterize the model such that the parameters are the (marginal) WTP for each attribute rather than the utility coefficient of each attribute. Such an approach is referred to as an estimate in the "WTP space", whereas the former is known as taking place in the "preference space". It can be demonstrated (Train and Weeks, 2005; Scarpa et al., 2008) that the two approaches are formally equivalent, in the sense that any distribution of coefficients translates into some derivable distribution of WTP's, and vice-versa. However, they differ in terms of numerical convenience.

5. Econometric estimates

We illustrate below the estimates of the MNL and the RPL models. The former is estimated with the Limdep\Nlogit software (http://www.limdep.com/products/nlogit/), while the latter is estimated partly with the Nlogit and partly (for the WTP state specification) with the Apollo package in R (www.ApolloChoiceModelling.com).

5.1. The multinomial logit model

This section presents the results of a MNL model that, in our case, since the alternatives are only two, could be more properly termed binary logit model. Amongst the specifications tested, the one with the largest set of significant parameters and the highest explanatory power is presented in Table 5. We first estimated the model using all observations, and then discarding the 102

Table 5
Results of the MNL model specification.

Variable	*Coefficients*	*Std. Error*	*t-stat*	*Implied WTP*
Attributes				
ASC_EV	1.5614***	0.2177	7.2	13,455
Purchase price (€ 10,000)	−1.1605***	0.0443	−26.2	
Fuel economy (€ per 100 km)	−0.0349***	0.0067	−5.2	−300.4
EV range (100 km)	0.333***	0.0337	9.9	28.7
Petrol car range (100 km)	0.09***	0.0119	7.6	7.8
VW vs Daimler	0.8837***	0.0911	9.7	7615
Renault vs Daimler	0.6763***	0.0599	11.3	5827
Nissan vs Daimler	0.837***	0.0773	10.8	7212
BMW vs Daimler	0.8599***	0.0818	10.5	7409
Fast charging time (minutes)	−0.0101***	0.0019	−5.2	−86.8
Max distance btw charging stations (km)	0.0007	0.0010	0.7	
Free parking (hours)	0.0122***	0.0023	5.3	1.8
Socio-economic characteristics				
Age	−0.0091***	0.0018	−5.1	11,883 (20 years) 9132 (55 years)
Level of education	−0.048**	0.0192	−2.5	13,041 (least educated), 11.387 (most educated)
Family members with license	0.0493**	0.0213	2.3	14,304 (2 licenses)
Owned garage	0.0768	0.0473	1.6	14,117 (with garage); 13,455 (without garage)
Trips longer than 400 km per year	−0.0037*	0.0022	−1.7	13,423 (< 11 trips); 13.455 (> =11 trips)
EV knowledge	0.0364***	0.0139	2.6	13,768 (lowest); 15,650 (highest)
EV driving experience	0.0123	0.0619	0.2	
Environmental association	0.2373***	0.0558	4.2	15,499 (member); 13,455 (non-member)
Environmental concern	−0.1986***	0.0322	−6.2	11,743 (strongly agree), 6608 (strongly disagree)
Model diagnostics				
N. obs.	10,728			
Adjusted Rho-squared	0.12161			
Predictive capability (predicted vs actual)	58,31%			

lexicographic choices. The two estimates do not differ significantly. We opted for the one based on the 894 non-lexicographic interviews.

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[6]; 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.

The socio-economic, mobility and informational characteristics of our sample have been specified in the model. We observe these results. Younger respondents have a more positive attitude towards EVs. On the contrary and surprisingly, respondents with higher education levels derive lower utility from EVs. Garage ownership plays a role in the positive interest towards EVs, but the coefficient is not significant. Hence, the decisive importance of owning a garage not to rely on the public charging infrastructure and to reduce the total cost of ownership of an EV is not perceived by our sample. The coefficient associated with the variable *Trips longer than 400 km per year* is negative, as expected, but also only moderately significant.

The self-declared level of *EV knowledge* increases the positive attitude towards EVs, in line with the results of Barth et al. (2016) and Schmalfuß et al. (2017), while the *EV driving experience* parameter is not significant. Concerning the latter finding, there is inconclusive evidence: some authors document a positive association (Larson et al., 2014; Turrentine et al., 2011), whilst others do not support it (Bühler et al., 2014). Environmental awareness plays an important role in the choice of an EV. We find that the variable *Environmental association* has a positive and significant coefficient. A strong preference for EVs also emerges from the negative and significant coefficient associated with *Environmental concern*.[7] These results are consistent with the literature (Flamm, 2009; Hidrue et al., 2011; Carley et al., 2013; Priessner et al., 2018). Other socio-economic variables such as *gender, number of cars in the household, family income, average number of km travelled per day, average number of km travelled per year,* and living in *small towns* were excluded from the final specification because resulted not statistically significant.

Finally, we compute the consumers' WTP in terms of the purchase price increase that generates the same level of (dis)utility of an attribute's unitary variation. The WTP estimates are reported in the last column of Table 5. *Ceteris paribus*, our Italian sample is willing to pay between €2600 and €14,600 more for an EV[8], showing a positive attitude towards EVs. This result is surprising and contrasts with Valeri and Danielis (2015), Valeri and Cherchi (2016) and Giansoldati et al. (2018) that find, as summarized in Table 1, a negative ASC_EV coefficient and, hence, a negative WTP. This finding might signal a change in the Italian consumers' perception. At international level, positive ASC_EV coefficients are reported in recent studies only by Mabit and Fosgerau (2011) for Denmark and Langbroek et al. (2016) for Sweden, while most of the previous studies reported negative coefficients. Some studies report positive values only for subsamples (Dagsvik et al., 2002; Ewing and Sarigöllü, 1998) or for specific segments of the population (Hackbarth and Madlener, 2016; Parsons et al., 2014). Qian et al. (2019) find a statistically non-significant value.

Respondents value €300 an increase in fuel economy of €1 every 100 km. The estimate is reasonable: since an Italian car driver travels on average about 10,250 km\year, a €1/100 km fuel saving implies an annual saving of €134 (assuming a fuel consumption of 5 L/100 km and 1.60 €/liter for petrol). Hence, the payback period is less than 3 years. Other authors find similar WTP values. Jensen et al. (2013) and Hackbarth and Madlener (2013, 2016) find values in the range €79-200, €530-1070, and of €1056, respectively.

Respondents value €29 an additional kilometer of EV driving range (€8 for petrol car driving range). The estimate is lower than the one previously found for Italy as summarized in Table 1 (equal to €50, €42 and €101) and signals a reduced sensitivity to the driving range, presumably due to the increase in the average range of EVs and to the growing density of the charging network. It is also lower than most estimates reported in other international studies (with the exception of Hackbarth and Madlener, 2013) as illustrated in Table 6. In a meta-analysis on 33 primary studies on up to 2012 published papers, Dimitropulous et al. (2013) find average values ranging from 36.6 to 41.6 €\km. Although differences in model specification, sample size and control variable might influence the implied WTP, our finding might signal a variation in the sensitivity towards a crucial limitation of EVs.

Fast charging time is valued €87 per minute saved. The comparison with other findings is difficult since the metrics and the

[6] Hensher (2006) states that "although our findings indicate that the number of attributes ignored tends to increase as the number of levels of each attribute increases, as the range of each attribute narrows and as the number of alternatives decreases, this finding cannot be a guide as to what is the 'optimal' design from a behavioural perspective".

[7] This is the case since the variable is built as an inverted Likert scale where the lowest values express an increased concern for the environmental condition where the respondent lives/works/studies.

[8] Assuming a respondent with very favourable socio-economic characteristics (age: 18; university degree; licences in the household: 3; high EV knowledge: 7; member of environmental association; with strong environmental concerns: 1), we obtain a WTP equal to €14,600 to own an EV, regardless of the car attributes. Assuming a respondent with very unfavourable socio-economic characteristics (age: 65; high school diploma; licences in the household: 4; low EV knowledge: 1; not member of environmental association; with weak environmental concerns: 4), we obtain a WTP equal to €2600 to own an EV, regardless of the car attributes.

Table 6
Comparison of WTP estimates among recent international (mostly European) studies.

Authors	Year of the study	Country	Driving range EV (€/km)	Driving range petrol car (€/km)
Qian et al. (2019)	2015	China	83[a]	
Cherchi (2017)	2014–2015	Denmark	46	2.3
Langbroek et al. (2016)	2014	Sweden		
Bahamonde-Birke and Hanappi (2016)	2013	Austria	327	
Hackbarth and Madlener (2016)	2011	Germany		
Hackbarth and Madlener (2013)	2011	Germany	16-33[a]	8-17[a]
Jensen et al. (2013)	2011	Denmark	46 to 65 before, 84 and 134 after the EV driving experience[a]	3[a]
Hoen and Koetse (2014)	2011	Netherlands	52[a]	
Mabit and Fosgerau (2011)	2007	Denmark		
Dimitropulous (2013): meta-analysis	up to 2011	various countries	36.6 to 41.6[a]	

[a] Values reported by the authors. The remaining values are our estimates, based on the reported coefficients and converted to Euros without adjusting for inflation or for the purchasing power difference.

modelling of charging time differ greatly among studies. Our estimate is consistent with the result obtained by Qian et al. (2019). They find a value of €182 and underline that Chinese respondents are affected by a certain degree of "Easterners" impatience. Previous studies estimate the WTP for charging considering also the slow charging modes. Consequently, they report marginal WTPs per minute not comparable with our estimate. For instance, Hackbarth and Madlener (2013), Hoen and Koetse (2014), Hackbarth and Madlener (2016) report values of €18, €24, between €5 and €194, respectively.

The possibility to park free of charge is valued €1.8 for an hour of free parking. Assuming that the car is parked for eight hours per day for five days per week for 48 weeks, the value corresponds to a yearly saving of €3840. This is hardly comparable with other contributions since most of them do not take into consideration a specific number of hours of free parking, but just the possibility to park free of charge. Langbroek et al. (2016) estimate for Sweden an annual value of €5665. Hoen and Koetse (2014) and Hess et al. (2012b) report a WTP of €377 and €462-1663, respectively.

With reference to the brand\model attribute, we find that, irrespective of the fuel technology, respondents value a Volkswagen Golf\e-Golf, a Renault Clio\Zoe, a Nissan Qashqai \Leaf, a BMW Series 1\i3 respectively €7615, €5827, €7212, €7409, more than the Daimler Smart forfour Petrol/EV.

5.2. *The random parameter logit model*

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 7 three specifications. The first two are estimated in the preference space, while the last one in the WTP space.

The variables *ASC_EV, Purchase price* and *EV range* are assumed to be normally distributed[9] and the panel dimension (each individual provides 12 correlated choices) is accounted for. From the first two columns of Table 7 we see that the RPL estimates confirm the results obtained with the MNL specification, both in terms of sign and statistical significance. The only exception regards the variable linked with charging network density, that becomes significant but with a counter-intuitive positive sign. All three attributes assumed randomly distributed have a significant standard deviation, which is higher in the case of the *Purchase price* and the *ASC_EV*. With regards to the socio-economic variables, only the variables *Trips longer than 400 km per year, Environmental association* and *Environmental concern* are significant. Both *EV knowledge* and *EV driving experience* lose significance.

Next, in columns 3 and 4 (Table 7) 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.

The third model specification (columns 5 and 6 in Table 7) is in the WTP space along the lines suggested by Train and Weeks (2005) and Scarpa et al. (2008). The reported coefficients should, however, be adjusted for the measurement units used to code the data. Some of the WTP estimates derived from the MNL model are similar to those obtained in this specification of the model. The base value of the ASC_EV is similar to the MNL model (€13,580 vs. €13,455), the EV_range is valued €20.4 instead of €28.7, and the petrol car range is valued €5.0 instead of €7.8. The brand\model valuations are approximately €1000–2000 lower, while the value of a minute saved in fast charging decreases from €86.8 to €9. On the contrary, the value of an hour of free parking increases from €1.8 to €6.

[9] We have also tested alternative parameters distributions but we do not report them in the interest of space. The triangular distribution with parameters constrained only on the negative (for purchase price) or positive axis (for driving range) generates similar estimates, whereas the lognormal distribution does generate parameters with counter-intuitive signs.

Table 7
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	

5.3. Comparison with a previous Italian survey

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.

Although it is evident that it is theoretically incorrect to pool together data collected with two different questionnaires and population, we curiously pooled the two datasets and tested the impact of a year dummy. We estimated both a MNL and a RPL model. Results are reported in Tables 8 and 9, respectively.

Firstly, we estimated a MNL model for each dataset separately. Comparing the results, we notice that the ASC_EV is negative with the 2017 dataset and positive with the 2018 one. Relevant differences appear also with regard to the sensitivity towards the purchase price and the network density. We then pooled the two datasets and introduced the 2018 dummy variable finding, obviously, similar results.

Secondly, we estimated a RPL model with all vehicle attributes (but the brand\models) normally distributed with a 2018 dummy covariate. The previous results are confirmed, indicating a significant change in the preference structure of the Italian drivers, in particular regarding the determinants not included in the systematic utility components, which turn from negative to positive.

Table 8
Results of the MNL model specification.

	Dataset 2017		Dataset 2018		Joint dataset	
	Coeff.	*t - ratio*	*Coeff.*	*t - ratio*	*Coeff.*	*t - ratio*
ASC_EV	−0.558***	−3.8	0.583***	5.6	−0.564***	−4.0
ASC_EV *2018 dummy					1.208***	6.8
Purchase price (€ 10,000)	−0.023***	−2.8	−0.735***	−27.3	−0.013*	−1.6
Price *2018 dummy					−0.759***	−29.2
EV range (100 km)	0.185***	3.9	0.250***	7.7	0.168***	3.6
EV range *2018 dummy					0.063	1.1
Petrol car range (100 km)	0.050***	4.3	0.094***	9.3	0.041***	7.7
Petrol car range *2018 dummy					0.052***	7.9
Max distance btw charging stations (km)	0.014***	6.2	0.003***	2.9	0.012***	6.5
Max distance btw charging stations *2018 dummy					−0.009***	5.6
VW vs Daimler&BMW	0.594***	9.4	0.044	0.7	0.327***	−3.9
Renault vs Daimler&BMW	0.197***	3.1	0.248***	5.5	0.286***	3.5
Nissan vs Daimler&BMW	0.142**	1.9	0.185***	3.4	0.274***	3.4
Model diagnostics						
N. of observations	3400		10,728		14,128	
N. of parameters	8		8		13	
Adjusted Rho square (constants only)	0.0305		0.0979		0.0773	

Table 9
Results of the RPL model specification.

	Coefficient	t - ratio
ASC_EV	−0.800***	−4.5
• SD of ASC_EV	0.883***	11.7
• ASC : dummy 2018	1.362***	6.2
Purchase price (€ 10,000)	−0.056	−1.1
• SD of Purchase price	0.639***	19.1
• Purchase price: 2018 dummy	−1.052***	−16.8
EV range (100 km)	0.254***	4.3
• SD of EV range	0.009	0.2
• EV range : 2018 dummy	0.115*	1.6
Petrol car range (100 km)	0.067***	4.4
• SD of Petrol car range	0.072***	6.8
• Petrol car range: dummy 2018	0.067***	4.4
Max distance btw charging stations (km)	0.019***	6.9
• SD of Max distance btw charging stations	0.000	0.3
• Max distance btw charging stations: dummy 2018	−0.013***	−4.6
VW vs Daimler&BMW	0.473***	9.2
Renault vs Daimler&BMW	0.416***	9.7
Nissan vs Daimler&BMW	0.420***	8.4
Model diagnostic		
N. of observations	10,728	
N. of parameters	18	
Adjusted Rho square (constants only)	0. 1410	

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.

6. Scenario analysis

Based on the RPL results, we simulate how the probability of buying an EV model versus the corresponding petrol car model of the same brand would change as a result of an assumed scenario. Firstly, we estimate such probabilities using a base line scenario (attribute values: current EV range, no subsidy, no free parking, current fast charging time, and average EV knowledge). The baseline estimate is on average slightly higher than the 2018 EV market share[10] (5.3% vs. 2.5%), the VW eGolf being the most over-estimated

[10] We report the comparison between the electric Daimler Smart fortwo and the corresponding petrol model, since there is no information on the

Table 10
Scenario analysis.

Scenario\Brands	BMW i-3	VW eGolf	Renault Zoe	Nissan Leaf	Daimler Smartforfour ED	Average
2018 market share	2.1%	0.3%	2.0%	2.0%	6.0%	2.5%
Estimated baseline[a]	3.1%	4.7%	3.6%	5.3%	9.7%	5.3%
Scenario 1: €6000 subsidy	8.4%	12.6%	9.8%	13.9%	23.7%	13.7%
Scenario 2: free parking from 0 h to 24 h	5.0%	7.7%	5.9%	8.5%	15.2%	8.5%
Scenario 3: +50% EV range	4.4%	9.5%	7.3%	10.5%	12.6%	8.9%
Scenario 4: fast charging time from 55 to 30 min.	3.8%	5.8%	4.5%	6.4%	11.7%	6.4%
Scenario 5 = Scenario 1 + 2: financial policies	13.4%	19.5%	15.5%	21.3%	34.3%	20.8%
Scenario 6 = Scenario 3 + 4: technological improvements	5.4%	11.5%	8.9%	12.7%	15.2%	10.7%

[a] Current EV range, no subsidy, no free parking, current fast charging time, average EV knowledge.

(Table 10). The main explanation is, of course, that we use stated instead of revealed preference data. Secondly, there might be car supply constraints that inhibit intended choices to be realized. We then vary the attribute levels as follows:

- Scenario 1: €6000 subsidy on purchase price;
- Scenario 2: free parking from 0 h to 24 h;
- Scenario 3: increase in the EV range by 50%;
- Scenario 4: decrease in the fast charging time from 55 to 30 min;
- Scenario 5 = Scenario 1 + 2: financial incentives;
- Scenario 6 = Scenario 3 + 4: technological improvements.

Scenario 1 is inspired by the "Ecobonus", a purchase subsidy introduced in Italy in March 2019, which finances up to €6000 the acquisition of a new car whose CO_2 emissions are lower than 20 g/km[11]. Scenario 2 reflects the case of some Italian cities (Milan, Rome) that allow free parking in restricted traffic zones. Scenario 3 and 4 assume realistic technological improvements. In fact, it is well documented that EV average range is constantly increasing (e.g. Nykvist et al., 2019), reaching an average value of about 280 km,[12] making EV drivers almost free of the so-called "range anxiety" issue. Results are summarized in Table 10. On average, the €6000 purchase subsidy (Scenario 1) increases the probability of buying an EV over the baseline scenario by 8.4%. The shift from no free parking to unlimited free parking raises the probability on average by 3.2%. A 50% driving range increase (Scenario 3) would increase the probability by 3.6%. The reduction of fast charging time from 55 to 30 min has the effect of increasing the probability to choose an EV by 1.1%. The two combined financial incentivizing policies would increase the probability on average by 15.5%. The two combined technological improvements would increase the probability on average by 5.5%. The implied message is that our Italian sample is more cost sensitive than performance sensitive, in the sense that the EV uptake is more dependent on the financial benefits of buying and using an EV than on the current driving range and charging time limitations.

The above conclusion is confirmed when analysing the impacts of the 6 scenarios on the specific car models considered. The Daimler Smart forfour ED, being the car with the lowest purchase price, appears to have the highest market potential.

7. Conclusion and policy implications

So far, Italy had a low EV market penetration rate, although the country enjoys some characteristics that could favor EV uptake. The mobility needs are well in line with the current EVs driving range. Almost all our sampled respondents (97%) travel less than 100 km per day and trips longer than 400 km are not frequent. Car ownership is high so that an EV could be used as a second family car (in our sample 62% of the families own at least two cars). Most of the respondents (70%) own a garage, which facilitates home charging at cheaper rates. Some characteristics are, however, unfavourable. The annual distance travelled is relatively short. The Italian average is about 10,250 km. In our sample, only 16% of the respondents drive more than 20 thousand km per year, while EVs require high annual travelled distances in order for their total cost of ownership to be cost competitive with that of conventional cars (Danielis et al., 2018; Scorrano et al., 2020a). In our view, however, the main difficulty with the Italian car market is that most of the demand is for the small to medium car segment where so far the number of EVs available on the market is limited and much more

(footnote continued)
petrol version of Daimler Smart forfour.

[11] According to the "Ecobonus" measure, buyers are entitled to benefit from the maximum amount of the subsidy when the purchase of a new car is associated to the scrapping of an old one. The new car must have a price lower than €50,000. Detailed information on the policy enacted from April 1st, 2019 by the Italian ministry for infrastructures and transportation in cooperation with the Italian ministry for economic development are provided at the following URL: https://ecobonus.mise.gov.it/ (in Italian, last accessed on April 11th, 2019).

[12] The data is the average of the two values indicated at the following URL: https://www.motoringresearch.com/advice/electric-hybrid/electric-car-buyers-guide/ (last accessed on April 11th, 2019). Driving range increases, however, achieved equipping vehicles with larger batteries, fully offset the battery cost decrease, holding the average EV purchase cost constant or even slightly increasing https://www.bloomberg.com/news/articles/2019–01-06/before-the-electric-car-takes-over-someone-needs-to-reinvent-the-battery (last accessed on April 11th, 2019).

expensive than the equivalent conventional cars. In addition, the main Italian car manufacturer, FCA, has so far refrained from offering a compelling EV in that car segment.

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.

Another difference between Italy and other Northern European countries is that up to April 2019, in Italy the financial subsidies for EVs were limited to the circulation tax exemption and to scattered purchase subsides administered by some Regions. Starting from April 1st, 2019, the "Ecobonus" subsidy is provided at national level. It is planned to last three years and with a reasonable financial allowance. Given our results, such a measure will enhance EV diffusion, which, in turn, will enhance EV acceptance and reinforce EV uptake. Scientists, policy makers, social media and car manufactures could play an important role in strengthening this effect by providing reliable information on the technical, environmental and economic characteristics of EVs.

A specific point to be addressed is the charging issue, which currently seems to play no role in consumers' stated intentions. Currently, Italy is lagging behind in terms of public charging infrastructure and regulation[13]. Progress, however, has been made in the last years, and the largest charging station provider, ENEL X, a branch of the national energy provider ENEL Spa, is in the process of extending the charging network from 5400 in the year 2018 to 10,000 charging points, a high proportion of them, however, having only slow charging capability.

Our future research plans include: a) extending the survey to other European countries where the EVs uptake is, as in Italy, still low to confirm our results, or b) carry out a similar survey in country with high EV uptake to contrast the consumers' preference structure, and c) focus on specific car market- or population-segments.

As many stated choice experiments, our survey suffers from various limitations. Being a stated choice exercise, an evident limitation is the hypothetical bias, partly unavoidable in the initial phase of a new product deployment. As the EV availability increases, possible strategies to overcome the issue and improve on the realism of the hypothetical scenarios include: a) combining stated and revealed preference data (Brownstone et al., 2000); b) interviewing recent buyers pivoting on the past choice; or c) carry out face-to-face interviews with people that plan to buy a car in the near future.

As argued in the paper, the choice of attributes is crucial. When the hypothetical choices involve EVs and car equipped with conventional internal combustion engines, researchers typically include common attributes (e.g., price, acceleration, driving range, fuel cost) and BEV specific attributes (charging time, charging network density). Since the number of attributes that can be included is limited, to avoid over-complexity in the choice description, some EV specific attributes tend to be overlooked. Examples are battery warranty and residual value loss, as pointed out by Li et al. (2020), both associated with the risk of battery degradation, which is still a main concern to EV buyers. Another overlooked cost component seldom specified in the hypothetical scenarios (including ours) is associated with the different charging possibilities that might range from free charging, home charging, charging at work or fast charging. How these possibilities affect the preferences for EVs is a topic that requires more attention.

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

[13] As of April 2019, Italy has 228 CCS Combo DC chargers versus 1735 in Germany, 1268 in the UK and 625 in France. (https://insideevs.com/news/347133/ccs-7000-dc-fast-chargers-europe/)

interactions might be required.

CRediT authorship contribution statement

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

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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