The slow uptake of electric cars in Italy and Slovenia. Evidence from a stated-preference survey and the role of knowledge and environmental awareness

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We report the results of a stated preference study (N = 1,934) carried out at the end of 2018 on consumers' choices between electric cars and petrol cars in Italy and Slovenia. We estimate a hybrid mixed logit model that takes into account vehicle, infrastructure and policy attributes and two attitudinal attributes, i.e. environmental awareness and electric car knowledge. We find that purchase price and driving range play a crucial role in consumers' decisions in both countries, whereas charging time is not statistically significant. Comparing the two countries, price sensitivity is relatively stronger in Italy, while the sensitivity for driving range and fuel economy is relatively stronger in Slovenia. Of the two latent variables we tested, we find that only environmental awareness has a statistically significant positive impact on the choice of electric cars and that it is stronger for Italians compared to Slovenians. The structural component of this latent variable indicates that women are more concerned about the environment than men, but only for the Slovenian subsample. Surprisingly, no statistically significant relationship is found between environmental awareness and age. Younger respondents are as concerned as older ones about the environment both in Italy and in Slovenia.

1. Introduction

Battery electric cars (from now on, we will use the widely adopted acronym BEV, Battery Electric Vehicles, though we will refer only to cars) are slowly gaining popularity in many European countries, but at different rates. According to ACEA (2020), BEVs reached in 2019 a 2.3% average market share in the EU + EFTA countries. The small group of countries which leads the way include Norway (42.4%), the Netherlands (13.9%) and Iceland (7.8%), followed by a group of countries with above average uptake levels including, in decreasing order, Sweden, Switzerland, Portugal, Ireland, Austria, and Denmark, with a BEV market share ranging from 4.4% to 2.5%. A third group of countries with slightly below average BEV uptake comprises France, Germany, Finland, United Kingdom, Belgium, Hungary, with a BEV market share going from 1.9% to 1.0%. Finally, there is a group of countries still in the initial phase of BEV uptake (below 1% market share). They are, in decreasing order, Romania, Spain, Slovenia (0.7%), Italy (0.6%), Latvia, Bulgaria, Lithuania, Czech Republic, Poland, Estonia, Greece and Slovakia.

Since a growing number of papers finds that BEVs have the potential to decrease CO_2 emissions and to improve air quality at the

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local level (e.g., Cox and Bauer, 2018 with reference to Switzerland; Knobloch et al., 2020 for 59 world regions), it is worthwhile to examine why some countries are lagging behind in the adoption of BEVs and which policy could be enacted to spur their uptake.

CO_2 emissions for a given car are the result of a detailed estimate of the lifecycle emissions associated with the manufacturing, maintenance and end-of-life of the glider, the powertrain (motors, power batteries, electrical converters, charging components, fuel cells, etc.), the energy storage components, the supply of energy carriers used for vehicle operation and the direct emissions from vehicle operation. Although, to the best of our knowledge, no life cycle analysis comparing propulsion systems has been recently performed for Italy and Slovenia (the most recent studies for Italy are Donateo et al., 2015; Rusich and Danielis, 2015), it is quite likely that BEVs will help reduce their overall CO_2 emissions. In fact, according to an estimate by Moro and Lonza (2018), Italy has a carbon intensity of gross electricity production (with upstream) of 427 gCO_2e/kWh and Slovenia of 329 gCO_2e/kWh (having a larger nuclear energy share). This translates, in their calculations, in an estimate for electric vehicle use of 60–80 gCO_2e/km for Italy and of 48–60 gCO_2e/km for Slovenia, vs. an estimated European average of 145 gCO_2e/km for diesel cars and of 178 gCO_2e/km for petrol cars.

Moreover, especially Italian cities suffer from unhealthy air quality. In the 2019 report on Air quality in Europe prepared by the European Environment Agency (henceforth EEA) (2019), Italy shows worrying concentration levels of NO_x, O_3, PM_{10} and $PM_{2.5}$, frequently exceeding the recommended limits set by Directive 2008/50/EC for the protection of human health. EEA estimates that in Italy there were a total of 1,183 years of life lost per 105 inhabitants (908 due to $PM_{2.5}$, 227 due to NO_x, and 48 due to O_3 exposure) against a EU28 average of 930. Slovenia also fares worse than the EU28 average, with a total of 996 years of life lost per 105 inhabitants (916 due to $PM_{2.5}$, 39 due to NO_x, and 41 due to O_3 exposure). Estimating the potential local air pollution reduction from substituting internal combustion engine vehicles (ICEVs) with BEVs is also problematic. Cox and Bauer (2018) argue that life cycle assessments of particulate matter and photochemical oxidant formation are similar for all powertrain types. However, due to their lack of direct exhaust emissions, BEVs have the potential to reduce air pollution in densely populated areas, transferring their air emissions to the regions where vehicles and their components are manufactured. In any case, it is commonly accepted that the environmental performance of BEVs requires low CO_2 electricity generation technologies and a high efficiency of the energy chain from electricity generation to the wheel.

With the goal of improving energy efficiency and reducing CO_2 emissions, Italy and Slovenia financed the MUSE project within the priority axis of the INTERREG Programme Italy-Slovenia. The project partners are academic institutions, public administrations and agencies for local development, located in the neighboring regions of the two countries, in particular in the western part of Slovenia and in Friuli Venezia Giulia (FVG), a region located in the northeastern part of Italy. Within the MUSE project, we were able to carry out a stated-preference survey ($N = 1,934$) aimed at evaluating the preferences of the Italian and Slovenian drivers for BEVs relative to ICEVs. We investigated the importance consumers assign to 7 attributes, 4 of them shared by both propulsion systems (brand\model type, purchase price, fuel\electricity costs, driving range with a full tank\charge) and 3 BEV-specific (time needed to fast charge the battery, fast charging station density, free parking). The aim of the study is to identify both common features and preference differences. Moreover, we explored the role played by two latent variables, which we termed as *Environmental awareness* and *BEV knowledge*, in shaping car choice, identifying their socio-economic determinants and country-specificities.

The paper contributes to the literature at least in two ways. First, it provides the first car choice study based on Slovenian stated-choice data and with a focus on BEVs, complementing the qualitative research published by Knez et al. (2014). Second, it performs a cross-country comparison of the car choice preference structure between Italian and Slovenian decision makers in order to identify and calibrate the national policies incentivizing BEV uptake and the development of cross-border mobility plans.

The paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the stated choice experiment and the data collection process. Section 4 presents the modelling framework, whilst Section 5 illustrates the results. Section 6 discusses the results and draws some conclusions.

2. Related literature

Over the years, many authors have reviewed the abundant literature on BEVs (Rezvani et al., 2015; Coffman et al., 2017; Li et al., 2017; Liao et al., 2017; Kumar and Alok, 2020). They clarified the numerous factors that influence BEV adoption including:

- vehicle technical attributes such as acceleration, driving range, battery degradation, maximum speed;
- economic attributes including purchase price, fuel economy, insurance cost, maintenance and repair costs, warranty;
- infrastructural variables such as slow and fast charging infrastructure, home and multi-house dwelling charging infrastructure;
- financial and non-financial policies including purchase subsidies, reduced circulation tax, access privileges, free parking, bus- and HOV- (high occupancy vehicle) lane accessibility;
- environmental attributes such as CO_2 emissions, local air pollutants emissions, noise, oil independence.

They also underlined the role played by:

- individual attitudes such as risk aversion, interest towards new technology, hysteresis, change aversion, environmental awareness;
- car and mobility habits, e.g. car and garage ownership, annual distance travelled, urban driving;
- car knowledge, information and driving experience;
- symbolic or social attributes such as norms, interpersonal judgments, social networks, or affirmation of identity;
- other socio-demographic factors, e.g. gender, age, education level, income and occupation.

Among the BEV technical attributes, driving range and battery degradation received special attention while acceleration and maximum speed were deemed less problematic. A large set of papers focused on the former. Dimitropoulos et al. (2013) evaluated via a metanalytical study the economic value of such attributes on the basis of a set of studies published up to the year 2012. Giansoldati et al. (2018) reviewed more contributions and presented an original estimate with specific reference to the Italian drivers. They found that in 2017 Italian car drivers were highly concerned with the BEV driving limitation and six times more willing to pay for a 1-km increase in driving range than ICEV drivers. The risk of battery degradation has also been consistently perceived as a barrier to BEV adoption in many studies (Graham-Rowe et al., 2012; She et al., 2017; Berkeley et al., 2018; Noel et al., 2020), including a recent Italian study by Danielis et al. (2020). Economic attributes, most importantly the purchase price closely linked to the battery cost, have been largely demonstrated to play a decisive role in preventing a more rapid BEV uptake (Danielis et al., 2020). Stated choice studies have consistently proved their importance in consumers' purchase decisions, thus underlining the need for financial incentives (Coffman et al., 2017; Kumar and Alok, 2020). The specific role of each cost component in determining the total cost of ownership has been also investigated. Danielis et al. (2018) and Scorrano et al. (2020) apply a total cost of ownership model to the Italian market. In order to overcome the barrier represented by the still larger initial cost of buying a BEV vs. an ICEV, various authors propose and discuss a number of financial and non-financial policies (e.g., Sierzchula et al., 2014; Bjerkan et al., 2016; Melton et al., 2017). In this paper, we assess the impact of granting free parking to BEVs, a policy enacted by many Italian and Slovenian local authorities in an effort to incentivize BEV adoption. Several studies confirmed that the unavailability of an adequate charging infrastructure is a major barrier for BEV diffusion, since it reduces flexibility and user convenience, making BEV driving a less attractive proposition (Sierzchula et al., 2014; Berkeley et al., 2018). A number of studies investigated the environmental dimension, either specifying emissions as an attribute of the vehicle (Hackbarth and Madlener, 2013, 2016) or exploring how consumers' preference for environmental outcomes can substantially impact their decisions to purchase a BEV, an issue we will discuss in detail in the next subsection.

As for the consumers' characteristics, various aspects have been analyzed including socio-economic status, mobility needs and habits, and psychological and attitudinal constructs. Since BEVs entered the market only in the last decade, concepts such as love-for-technology, early adoption or risk aversion were investigated (Jansson et al., 2017; Kumar and Alok, 2020). Social norms and identity and symbolic motivations were also identified as important (Cherchi, 2017; Kumar and Alok, 2020). Income and gender differences were documented to play a role. Given their driving limitations, BEVs were found to be more compatible with multi-car households or among users with limited daily commuting distances (Egbue and Long, 2012). More recently, thanks to the increasing BEV popularity, the substantial improvements in their driving range, the denser charging infrastructure and the higher BEV knowledge, the impact of the consumers' characteristics is being revaluated.

In the next paragraphs, we will focus our attention and review the literature on the role played by environmental awareness and BEV knowledge in shaping consumers' preferences and on the methodologies used to analyze how these factors determine consumers' intention to buy a specific car.

2.1. Environmental awareness

Since many studies have assumed that BEVs have the potential to reduce the environmental problems of the transportation sector, the literature on BEV adoption has frequently examined the relationship between pro-environmental attitudes and the intention to purchase BEVs. Almost a decade ago, Skippon and Garwood (2011) found that some UK BEV adopters expressed protecting the environment as a motivation for their car choice. Egbue and Long (2012) documented a similar finding surveying 21 US cities. However, Graham-Rowe et al. (2012) reported that UK consumers expressed doubts about the positive environmental consequences of BEV adoption because of the environmental impacts of battery production and electricity generation. Hence, they signal the need to jointly consider the issue of reducing the environmental impact of electricity generation and battery production in order to lower the lifecycle impact of BEVs and, in turn, communicate their environmental benefits. In fact, a study by Axsen and Kurani (2013) showed that coupling green electricity and BEVs will increase the intentions to adopt BEVs in some consumer groups in the USA. The authors further explored this issue in a series of other papers. Axsen et al. (2015) constructed lifestyle-based segments using cluster analysis on a subset of potential early Plug-in Electric Vehicle (PEV) buyers. Although they find a high level of heterogeneity, they concluded that the interest towards PEVs is generally associated with engagement in certain lifestyles and environmental awareness. In a follow-up paper (Axsen et al., 2016) they stated that early PEV buyers tend to have different motivations, including significantly higher levels of environmental awareness, and higher engagement in environment- and technology-oriented lifestyles. Surveying Dutch respondents, Quak et al. (2016) confirmed that strong environmental performance is an important motivator for BEV acceptance. Smith et al. (2017) studied the environmental enthusiast bias and found that Australian drivers with environmental awareness have higher adoption intentions for BEV. Hackbarth and Madlener (2016) confirmed that early adopters of BEVs in Germany are likely to be more environmentally aware. Degirmenci and Breitner (2017) investigated in a German sample the role of environmental performance relative to price and range regarding consumer purchase intentions for BEVs. They found that the environmental performance of BEVs is a stronger predictor of attitude and thus purchase intention than price value and range confidence. Haustein and Jensen (2018) surveyed Danish and Swedish respondents and concluded that people who would feel proud when having a BEV and think that BEVs express environmental awareness and openness for new technologies are more likely to consider buying a BEV. Soto et al. (2018a) showed that environmental awareness and the support for green transport policies have a positive influence on the intention to purchase alternative fuel vehicles. Kormos et al. (2019) found that respondents who prefer BEVs tend to have higher levels of environmental awareness and environmental-oriented lifestyle engagement. Interestingly, Orlov and Kallbekken (2019) performed a regression analysis of the actual choices of Norwegian car buyers. They did not find any significant impact on the adoption of BEVs with respect to the statements "Buying a more energy efficient car would reduce my household's environmental impact" and "Please rate how concerned you are about the environment". Similarly, Figenbaum and Nordbakke (2019) found that the percentage of Norwegians who perceive the environmental benefit of BEVs as a large advantage reduced between 2016 and 2018, while a larger percentage of Norwegians perceive them as neither having an advantage nor a disadvantage. This result, however, might be country specific and associated with the normalization of BEVs as a regular vehicle option among Norwegian consumers.

To summarize, there appears to be a sufficiently strong evidence, with some exceptions, that environmental concern, in its many facets (interest for the environment, willingness to be recognized as environmentally aware, moral obligation to protect the environment), is generally associated with the intention to buy a BEV or of preference for a BEV versus an ICEV. Our paper will explore the role of environmental awareness in the choice of a BEV for Italian and Slovenian respondents.

2.2. *BEV knowledge*

In an increasing complex society characterized by a large variety of products, consumer-oriented product information might play a relevant role in consumer's choices (Gustafson, 2015). According to some authors (Agnew and Szykman, 2005; Miller and Cassady, 2012), increased knowledge about the available products reduces the cognitive costs of processing information. BEVs represent a radical innovation in the car market, challenging consumers with new questions regarding battery degradation, car performance, fire safety, residual value loss, charging issues and so on. Consequently, it is not surprising that several papers analyze the role of knowledge in favoring BEV uptake. In a pioneering study, Krause et al. (2013) found that only two-thirds of their respondents provided correct answers to basic factual questions about BEVs (e.g., purchase price, vehicle maintenance cost, driving range, and recharging time), and only 55% correctly estimated their private value or advantages. They reported several misperceptions about purchase price, fuel consumption and maintenance savings, and concluded that better informing consumers about already available public incentives and advantageous aspects of BEVs offered promising steps toward their uptake.

Along the same lines, Burgess et al. (2013) argued that practical experience is an important factor in converting the attitude of consumers from skepticism to support and acceptance. They found that by driving BEVs consumers begin to perceive them more positively, especially in terms of speed, acceleration, and low noise. Jensen et al. (2013, 2014) tested such an idea. They gathered data before and after individuals experienced a BEV in real life during a three-month period with the aim to assess the impact of the direct experience of using a BEV on individual preferences and attitudes. Contrary to the Burgess et al. (2013)'s argument, they found that the real life experience decreased by 50% the probability of buying a BEV. Women expressed a positive view of the BEV driving performance but several respondents showed concern about the possibility of maintaining their current mobility. Bühler et al. (2014) also conducted a six-month trial with participants who have driven a BEV in the Berlin metropolitan area and analyzed their evaluation at three data collection points (before receiving the BEV, after 3 and 6 months of usage). Participants reported a wide range of advantages, but also barriers to acceptance. The authors concluded that experience had a significant positive effect on the general perception of BEVs but not on attitudes and purchase intentions. They argued, however, that providing real-life experience could be a promising marketing strategy. Skippon et al. (2016) reported similar findings, after conducting a randomized controlled trial. They found that although the BEV performance is rated superior than that of the conventional car, willingness to consider a BEV declined after experience, due mainly to the driving range limitations. In a similar fashion, Schmalfuß et al. (2017) conducted two studies: an online survey and a 24-hour field test. Both studies showed several experience-based differences in evaluations of BEV attributes, attitudes and purchase intentions, with most BEV attributes being evaluated more positively when people had experienced driving a BEV. However, the impact on purchase intention remained unclear: one study detected a positive effect on purchase intention, while the 24-hour field test showed no effect. However, the authors concluded that providing short term BEV experience has the potential to change BEV evaluation and might be a promising strategy for promoting BEVs.

As BEV uptake progresses in several countries, researchers have the possibility to test the impact of longer-term experience with driving a BEV and, consequently, a deeper knowledge of their pros and cons. For instance, Langbroek et al. (2019) studied the relationship between BEV rental and BEV adoption. They found that, although people who rent a BEV demonstrated a greater perceived and objective BEV knowledge, they did not seem to be more inclined towards BEV adoption. Thøgersen and Ebsen (2019) found that personal experience as a BEV owner led to a more positive attitude towards BEVs. They concluded that, in order to increase the demand for BEVs, the focus should be on reducing uncertainty and negative expectations. Broadbent et al. (2019) confirmed that information provided about BEVs increased the likelihood of positive attitudes towards BEV purchase and decreased uncertainty about the technology. Sovacool et al. (2019) carried out a research with Chinese respondents. They discovered that self-assessed knowledge ratings were not very high and that interviewees lacked knowledge of government policies to encourage BEV adoption. Their analysis indicates that a higher self-assessed knowledge is positively associated with BEV uptake but, interestingly, knowledge is not significantly associated with willingness to adopt BEVs, whereas experience with them is.

To summarize, evidence on the relationship between BEV knowledge in terms of both information and driving experience, and willingness to buy a BEV, does not seem to be clear-cut: some authors detected a positive relationship between knowledge and the general attitude towards BEVs, but not on the intention to buy them. However, other authors pointed out that higher levels of knowledge entail also a higher knowledge of BEV limitations, thus reducing the willingness to buy them. Such a relationship is most likely time dependent since the technological progress has considerably improved the BEV driving range at almost constant prices. Moreover, the relationship is likely to be also country-specific since the density and quality of the charging network might contribute to reduce range anxiety and charging time. Consequently, we thought it worthwhile to test the role of BEV knowledge in Italy and Slovenia.

2.3. Hybrid choice models

The papers we reviewed in the previous subsections use a variety of theoretical approaches and data analysis methodologies. They can be divided into two main groups: the theory of planned behavior and the discrete choice theory, with few exceptions, e.g. Langbroek et al. (2019), who refered to the protection motivation theory and the transtheoretical model of change, and Sovacool et al. (2019) who used multivariate analysis and principal component analysis. The theory of planned behavior has its origin in psychology (Ajzen, 1985) and links beliefs and behavior. It states that attitudes, subjective norms, and perceived behavioral control shape individual behavioral intentions. Such a theory is often operationalized via structural equation modelling (e.g., Degirmenci and Breitner, 2017; Schmalfuß et al., 2017; Haustein and Jensen, 2018). A derivation of the theory of planned behavior is the technology acceptance model (Davis, 1989) that describes how users come to accept and use a technology (e.g. Thøgersen and Ebsen, 2019). Discrete choice modelling, based on the random utility model (McFadden, 1974; Ben-Akiva and Lerman, 1985; Train, 2009), is widely applied in the transport literature. In the papers we reviewed it has been used in various specifications, as a simple multinomial logit model (e.g., Orlov and Kallbekken, 2019), as a latent class model (e.g., Axsen et al., 2015, 2016; Hackbarth and Madlener, 2016; Kormos et al., 2019), as a best-worst choice model (e.g., Smith et al., 2017) and as a hybrid model (e.g., Jensen et al., 2013).

Since we will adopt the latter methodology, it is worth recalling that the hybrid choice model has been strongly advocated by the pioneering papers by McFadden (1986) and Ben-Akiva et al. (2002). They set the stage for expanding the traditional discrete choice framework based on the random utility model to incorporate several elements of cognitive process, including strong dependence on history and context, perception formation, and latent constraints. Many contributions followed, dealing with different transport related-topics and countries. For instance, Bolduc et al. (2008) and Daziano and Bolduc (2013) analyzed car choice in Canada. Atasoy et al. (2010) studied mode choice in Switzerland including environmental awareness and the attitude towards public transport. Jensen et al. (2013) evaluated the stability of preferences and attitudes before and after experiencing a BEV in Denmark. Glerum et al. (2014) forecasted the demand for BEVs in Switzerland accounting for attitudes towards leasing contracts or practical aspects of a car in the decision-making process. Kim et al. (2014, 2016) studied the intended purchase of BEVs in the Netherlands allowing for a mixture of social influences and latent attitudes. Bahamonde-Birke and Hanappi (2016) studied the potential of electromobility in Austria. Two studies focus on the Italian transport market. Valeri and Cherchi (2016) studied the effect of habitual car use on an individual propensity to buy a specific type of engine technology. Sottile et al. (2017) studied the effect of awareness and individual attitudes on the switch from car to more sustainable modes such as park-and-ride. Using Danish data, Cherchi (2017) analyzed the effect of informational and normative conformity in the preference for BEVs. Soto et al. (2018a) evaluated the influence of policies, attitudes and perceptions when incentivizing alternative fuel vehicles in Colombia, while Soto et al. (2018b) analyzed parking behavior. Hess et al. (2018) used a hybrid choice model to analyze mode choice for intercity travel in the US. Pan et al. (2019) developed a BEV charging choice models for Chinese drivers incorporating risk attitude and different decision strategies.

3. Stated choice experiment and data collection

We estimate a hybrid mixed logit model, based on stated preference data collected via internet-based interviews, administered between October and December 2018 on a sample of the Italian (N = 996) and the Slovenian (N = 938) population using a CAWI (Computer Assisted Web Interviewing) questionnaire. SWG, a Trieste-based company specialized in market surveys, was in charge of the task and collected a total of 1,934 interviews. The sample was randomly drawn from the SWG Community that has over 60,000 members, who are paid to participate to the survey. Persons aged between 18 and 65 with a driving license were eligible to fill in the questionnaire. The starting sample was stratified by region of residence respecting predetermined gender and age shares. The parameters of the stratification and the sample shares were proportional to the distribution of the population derived from the most recent data made available by the Italian National Institute of Statistics (ISTAT) and the Statistical Office of the Republic of Slovenia (SURS).

The interviews consisted into two parts. In the first part, the respondent was asked to provide socio-economic data including personal information, car and garage availability, car mobility habits, BEV knowledge, and environmental awareness.

Table 1 contains descriptive statistics of the entire sample. The sample is made of 51% and 49% observations collected in Italy and Slovenia, respectively. The Italian sample includes 18 of the 20 Italian regions (only the Aosta Valley and Molise, the smallest Italian regions, are missing) and all the regions have a representativeness accurate at +\-10%. The Slovenian sample is distributed among all 12 Slovenian regions with a regional representativeness between −6% and +2%. The entire sample is balanced between men and women. In terms of age distribution, Italian respondents are relatively older. The largest group is between 35 and 44 years old, while the Slovenian largest group is the class between 25 and 34 years old. In terms of education, the share of respondents with a university degree is similar, but the share of respondents with a high-school degree is higher among the Italian respondents. The employment status is quite similar between the two countries, with most of the respondents being white-collar workers. The reported family income is higher for the Italian respondents, in accordance with the international GDP (PPP) statistics which rate Italy in 2018 at 39,499 and Slovenia at 36,566 international dollars (IMF WEO October 2018 Edition). However, in terms of perceived wealth, there is no relevant difference between the two groups of respondents. Car ownership is also very similar, with almost two thirds of the families owning more than a car. Garage availability is high (more than 70%), slightly higher for the Slovenian sample. In terms of mobility habits, the Italian sample drives annually slightly less. About 16% of the Italian and 21% of the Slovenian respondents drive more than 20 thousand km per year, which is a threshold that makes BEV cost-competitive with the conventional cars according to recent estimates (Wu et al., 2015; Danielis et al., 2018; Scorrano et al., 2020). A small number of interviewees perform round trips longer than 400 km, which is a distance requiring either a dense network of fast charging stations or BEVs characterized by longer driving range. The main

Table 1
Descriptive statistics.

	Italy	Slovenia
Number of interviews	996	938
Percentage of respondents in each area on the total sample of 1,934 respondents	51%	49%
SOCIO-ECONOMIC INFORMATION		
Gender		
Male	53%	50%
Female	47%	50%
Age		
From 18 to 24	10%	12%
From 25 to 34	18%	27%
From 35 to 44	25%	21%
From 45 to 54	24%	21%
From 55 to 65	23%	19%
Level of education		
Elementary school or middle school	5%	37%
Ongoing high school studies, or professional institute diploma, or high school diploma	43%	8%
Ongoing university studies or no university degree (but high school degree earned)	8%	9%
University diploma, or short undergraduate degree, or undergraduate degree or degree below the master level	35%	38%
Master or specialization school or doctorate	9%	8%
Current employment		
Entrepreneurs	16%	11%
Directors	10%	6%
White collars	47%	52%
Housewives and retirees	10%	11%
The unemployed	8%	6%
Students	8%	11%
Others	1%	3%
Family income		
Less than €30,000	47%	67%
Between €30,000 and €70,000	46%	31%
More than €70,000	7%	2%
Perceived level of wealth		
Reply to the question: "If you had to assess your economic condition, you would say that your family income allows you to live."		
Reply 1: "In a wealthy fashion";		
Reply 2: "Comfortably";		
Reply 3: "With some difficulties";		
Reply 4: "With several difficulties";		
Reply 5: "I feel I am poor".		
Reply 1	2%	1%
Reply 2	46%	47%
Reply 3	39%	37%
Reply 4	11%	13%
Reply 5	2%	2%
CAR AND GARAGE OWNERSHIP		
N. of owned cars in the household		
0	1%	2%
1	37%	35%
2	49%	44%
3	10%	14%
4	3%	4%
5	0%	1%
N. of individuals in the household who hold a driving license		
1	14%	12%
2	45%	42%
3	25%	28%
4	14%	15%
5	2%	2%
6	0%	1%
Availability of a garage		
Yes	71%	75%
No	29%	25%
CAR MOBILITY HABITS		
Average number of kilometers travelled per day		
≤ 10 km	28%	24%
11–50 km	55%	52%
51–100 km	14%	17%
>100 km	3%	7%
Average number of kilometers travelled per year		
≤ 5,000 km	24%	19%

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Table 1 (*continued*)

5001–10,000 km	24%	25%
10,001–20,000 km	36%	35%
20,001–50,000 km	14%	20%
>50,000 km	2%	1%
Number of yearly round trips by car over 400 km		
≤10	93%	94%
>10	7%	6%
Proximity to fast charging stations		
Reply to the following question: "Is there a fast charging station for BEVs near the place where you live/work/study?" Reply 1: "Yes", Reply 2: "No", Reply 3: "I do not know"		
Reply 1	39%	75%
Reply 2	39%	14%
Reply 3	22%	11%
ENVIRONMENTAL AWARENESS		
Environmental concern		
Reply to the following question: "The environmental situation in the place where I live increasingly worries me. "Reply 1: "Completely agree", Reply 2: "Quite agree", Reply 3: "Quite disagree", Reply 4: "Completely disagree"		
Reply 1	31%	23%
Reply 2	56%	52%
Reply 3	11%	20%
Reply 4	2%	5%
Environmental association		
Reply to the following question: "Have you ever participated to an environmental demonstration, or are you a member of an environmental association?"		
Yes	20%	10%
No	80%	90%
BEV KNOWLEDGE		
Self-assessed level of BEV knowledge (1=None, 7=Very high)		
1	12%	15%
2	18%	23%
3	20%	21%
4	15%	11%
5	23%	18%
6	8%	7%
7	4%	5%
BEV driving experience		
Yes	17%	19%
No	83%	81%

difference between the two samples regards the proximity to a fast charging station. Only 39% of Italian respondents reply positively to that question, while 75% of Slovenian interviewees give a positive answer. The statistical evidence confirms that the Italian fast charging infrastructure is less developed than the Slovenian one (Knez and Obrecht, 2017).

Finally, we report the answers to the indicators that we used to estimate the latent variables. The one we termed *Environmental awareness* is made up of two indicators: "Environmental concern" and "Environmental association". Italian respondents are more concerned about the environmental situation in the place where they live than the Slovenian ones, and a larger percentage of Italian respondents (20% vs. 10%) have participated to an environmental demonstration or are members of an environmental association. The respondents' perception of the worse air quality in the Italian cities vs. the Slovenian one is actually confirmed by the data. According to the environmental statistics of the EEA, Maribor and Ljubljana had in 2018 an annual average PM_{10} concentration level of 27.9 and 24.3 $\mu g/m^3$, respectively. In Italy, 23 cities had in 2018 an annual average PM_{10} concentration level higher than 30 $\mu g/m^3$, including large cities like Turin (35.9), Milan (33.5), Palermo (33.1), and only slightly lower Naples (29.7), Rome (27.7) and Florence (27.1).[1] The latent variable termed *BEV knowledge* consists of the indicators "Self-assessed level of BEV knowledge" and "BEV driving experience". In both cases, there are only small differences between the two national groups. The Slovenian respondents have a similar self-assessed level of BEV knowledge and a slightly higher number of them have driven a BEV.

The second part of the questionnaire consisted of 12 hypothetical choice scenarios similar to the one illustrated in Fig. 1. The choice tasks were introduced with the following statement: "Imagine having to buy a car. We will present 12 scenarios comparing each time a BEV and a petrol ICEV. The cars are described in terms of: 1) brand\model type, 2) purchase price, 3) cost of fuel or electricity, 4) driving range with a full tank\charge, 5) time needed to fast charge the battery, 6) maximum distance between fast charging stations, 7) free parking hours for BEVs only. We will ask you to indicate in each scenario which of the two cars you would choose taking into

[1] We retrieved the reported statistics from the following URL: https://www.eea.europa.eu/data-and-maps/dashboards/air-quality-statistics (last accessed on April 29th, 2020).

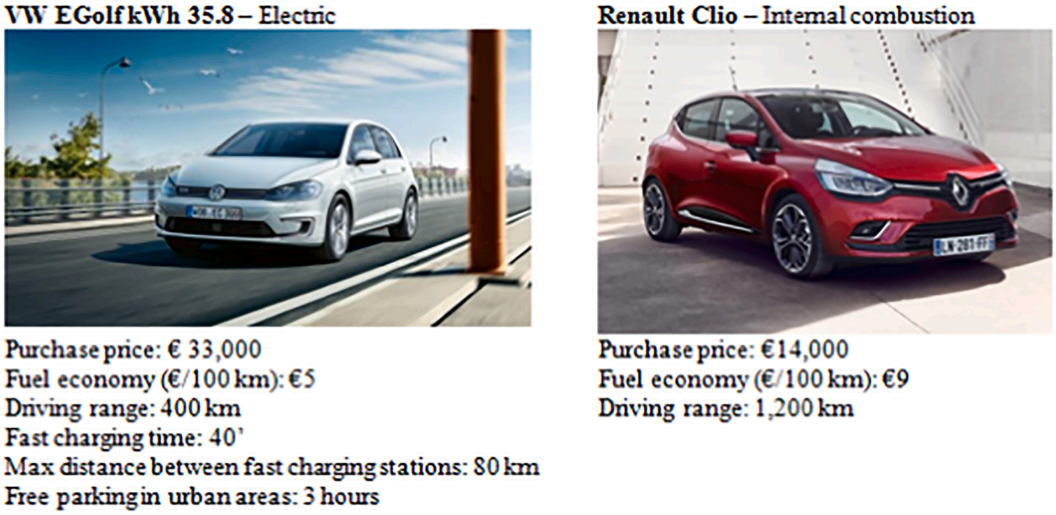

Fig. 1. Example of the choice tasks proposed to the respondents.

account your preferences and disposable income. Please take into account that the characteristics of the cars described in the 12 scenarios are hypothetical and might differ from the real ones."

The selection of the attributes to be included in the stated choice experiments is a critical choice for a stated preference study. The number of potential attributes is extremely large and their specification is also quite heterogeneous in terms of metrics (Greene et al., 2018). Based on Valeri and Danielis (2015), Giansoldati et al. (2017, 2018) and on the reviews by Liao et al. (2017) and Coffman et al. (2017), we chose the following attributes: purchase price, fuel economy, driving range, time required for a fast charge, maximum distance between fast charging stations and free parking time. The attribute levels are reported in Table A1 and in Table A2 in the Appendix. We assumed that BEVs purchase price could only decrease compared to the 2018 values, due to economies of scale and technological innovation, while for ICEVs we allowed for both a price decrease and increase. We assumed that the current BEV range could only improve, whilst the ICEV range might either increase or decrease. Charging time depends on many factors, the most important being: the type of charging station, the battery capacity, the battery type and the battery level to be recharged. We focused on charging time at fast charging stations assuming that it is more critical than charging time at home or at work where time constraint is generally less stringent. We used the following three levels to describe the hypothetical scenarios: 55′, which is the current time needed with a 50 kW charging station to recharge 80% of the battery, 40′, which is the current charging time with a 150 kW charging station, and 25′, assuming that in the future the technology of both the charging stations and the battery will further drastically improve reducing the charging time. Free parking time is set equal to 1, 3 or 24 hours, whilst the maximum distance between fast charging stations is described as being equal to 20 km, 50 km or 80 km.

We selected 5 pairs among the best-selling BEVs in Italy and Slovenia in 2018 and we compared them with their petrol counterparts. The BEVs we considered 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. 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 opted to focus on the more popular small\medium car segment (UNRAE, 2019).

As pointed out by Bradley (1988), "one would like to strike a balance between providing a great deal of contextual detail to familiarize the choice context to the specific respondent, and being able to apply the responses to a wider population and more general circumstances". In our specific case, the choice of using a CAWI method to collect our data limited the possibility to customize the stated choice experiment. Respondents were asked to image buying a car, but, differently from Jensen et al. (2014), we did not start the interview by asking them to state the details about their most likely next car purchase in terms of size and propulsion system; thus, we did not customize their alternatives on their selected car class. Another possibility to increase realism, adopted by Beck et al. (2011), is to include as a reference alternative the interviewees' most recent vehicle purchase and pivot the new alternatives to the reference one. Nonetheless, the alternatives we proposed are based on a careful analysis of the car market in Italy and Slovenia, both for ICEVs and BEVs. In an effort to achieve as much realism as possible, similarly to Eggers and Eggers (2011), our alternatives included the brand and the model of the car, but, unlike Eggers and Eggers (2011), the brand was not customized.[2]

A further controversial issue is how to familiarize respondents with the topic and whether and how to inform them on the

[2] To clarify, Eggers and Eggers (2011) phrased their question as follows: "Please assume that you want to buy a new car in the [compact] class. The model of the brand [Audi] that you prefer is available in the following drivetrain technologies. Which of these options would you buy? If none of the alternative drivetrain technologies is acceptable to you, you can choose the traditional gas or diesel option on the right."

characteristics of the products they are asked to choose from (Vass and Payne, 2017). Eggers and Eggers (2011), for instance, listed advantages and disadvantages of electric cars and asked respondents to rate the importance of the main attributes. Jensen et al. (2014) asked respondents to read three pages explaining what a BEV is, the charging options and their environmental effects to prevent misjudgments due to lack of knowledge. Our decision was not to include specific information on electric cars and their environmental characteristics. An advantage we have over previous studies on BEVs is that respondents are much more aware of their characteristics. Thus, avoiding to provide them with information (often controversial), besides saving precious survey time, allowed us to extract the respondents' preferences given their information set. However, other experimental designs are possible and they would most likely lead to different results, as other scholars have shown (Kløjgaard et al., 2012). In interpreting our findings, one should be aware of this caveat.

Using the Ngene Software, we developed an efficient design of the choice tasks (Bliemer and Rose, 2011). We used a pre-test carried out on 200 respondents interviewed in FVG in 2017 to build our a priori estimates (Collavizza et al., 2017).

4. Modelling framework

Following Soto et al. (2018b), we model the measurement equation as an ordered probit.

$$Z_{pcq} = \begin{cases} 1 \text{ } if \text{ } (-\infty) < Z^*_{pcq} \leq \tau_{pc1} \\ 2 \text{ } if \text{ } \tau_{pc1} < Z^*_{pcq} \leq \tau_{pc2} \\ 3 \text{ } if \text{ } \tau_{pc2} < Z^*_{pcq} \leq \tau_{pc3} \\ \dots \\ W \text{ } if \text{ } \tau_{pc(W-1)} < Z^*_{pcq} \leq \infty \end{cases} \tag{1}$$

$$Z^*_{pcq} = \gamma_{lpc} LV_{lcq} + \zeta_{pcq} \tag{2}$$

The categorical response of the indicator Z_{pcq}, where p denotes the indicator, c identifies the country, Italy (*IT*) vs. Slovenia (*SI*), and q detects the respondents, is defined by a set of threshold parameters τ to be estimated and by w which is the discrete choice response to the proposed statement for each indicator p. LV_{lcq} are the country and individual-specific latent variables with l identifying the latent variable ($l =$ *Environmental awareness* vs. *BEV knowledge*). ζ_{pcq} is the error term, assumed to be independent from γ_{lcp} and following a logistic distribution.

The structural equation of each latent variable LV_{lcq} is a function of r socio-economic characteristics SE_{rcq} of each respondent q of each country c and a normally distributed error term ϑ_{lcq}.

$$LV_{lcq} = \sum_r \alpha_{lcr} SE_{rcq} + \vartheta_{lcq} \tag{3}$$

Equations (4) and (5) describe the utility functions of the joint hybrid choice model for each a proposed alternative ($a =$ *BEV, ICEV*) and for each country specific subsample, Italian and Slovenian, respectively. The utility functions are assumed to be linear functions of the alternative specific constant ASC_{ac}, of the socio-economic characteristics SE_{rcq} of the respondents, of the latent variables LV_{lcq}, and of the k car-specific attributes X_{kca} characterizing each choice task and of an error term ε_{cq}.

$$U^{IT}_{aq} = ASC^{IT}_{a} + \sum_r \phi^{IT}_r SE^{IT}_{rq} + \sum_l \lambda^{IT}_r LV^{IT}_{lq} + \sum_k \beta^{IT}_{ka} X^{IT}_{ka} + \varepsilon^{IT}_{aq} \tag{4}$$

$$U^{SI}_{aq} = \xi\left(ASC^{SI}_{a} + \sum_r \phi^{SI}_r SE^{SI}_{rq} + \sum_l \lambda^{SI}_r LV^{SI}_{lq} + \sum_k \beta^{SI}_{ka} X^{SI}_{ka} + \varepsilon^{SI}_{aq} \right) \tag{5}$$

If we assume that the error term ε_{cq} is i.i.d. and has an extreme value type 1 distribution, the model is a simple logit model (in our case a binary logit model). On the contrary, if we allow for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time or individuals (Train, 2009), we need to reformulate the model as a mixed logit as follows:

$$U^{IT}_{aq} = ASC^{IT}_{aq} + \sum_r \phi^{IT}_r SE^{IT}_{rq} + \sum_l \lambda^{IT}_r LV^{IT}_{lq} + \sum_k \beta^{IT}_{kaq} X^{IT}_{ka} + \varepsilon^{IT}_{aq} \tag{6}$$

$$U^{SI}_{aq} = \xi\left(ASC^{SI}_{aq} + \sum_r \phi^{SI}_r SE^{SI}_{rq} + \sum_l \lambda^{SI}_r LV^{SI}_{lq} + \sum_k \beta^{SI}_{kaq} X^{SI}_{ka} + \varepsilon^{SI}_{aq} \right) \tag{7}$$

where β_{kacq} is the value that the coefficient of attribute k of alternative a has for individual q living in country c and represents that person's tastes. The value of these coefficients varies 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 β). This specification is the same as for the standard logit except that β varies over decision makers rather than being fixed. Since the probability is not a closed form as in the standard logit, 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 or more distributions (for the parameters and the error term). The model we have estimated has both the characteristics of a hybrid and of a mixed logit model. It is defined a hybrid mixed logit model (HMXL).

Since the effect of unobserved variables is likely to produce different variances for the error terms of the two country specific subsamples, we normalized to unity the variance of the Italian subsample, and we estimated the scale parameter ξ describing the relative variance of the Slovenian subsample compared to the Italian one (Brownstone et al., 2000; Jensen et al., 2013).

The latent variable *Environmental awareness* is measured by: a) self-assessed level of environmental concern, and b) being a member of an environmental association or having participated to an environmental demonstration. The latent variable *BEV knowledge* is measured by two indicators: a) the self-assessed level of expertise with BEVs, and b) the driving experience of a BEV. Fig. 2 shows the final structure of our HMXL model.

Table 2 shows the coding and measurement units used to describe the attributes of the hypothetical alternatives, the socio-economic characteristics of the respondents, and the measurement indicators. Additional details on the levels of each attribute are described in Tables A1 and A2 in the Appendix.

5. Results

One of the aims of the paper is to detect whether there are statistically significant differences in the stated choices between

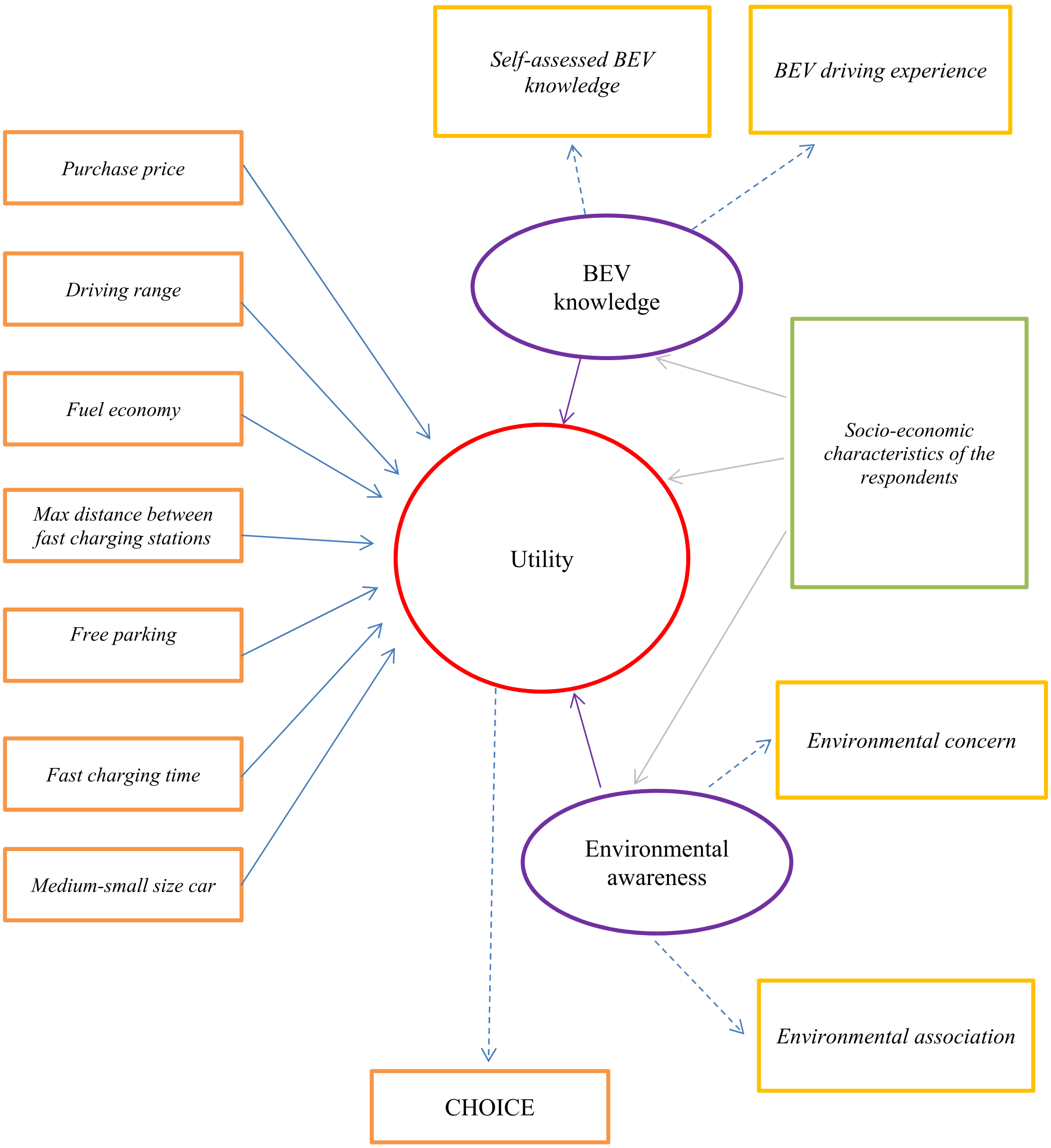

Fig. 2. Structure of the hybrid discrete choice model.

Table 2
Description of coding and measurement units of the variables used in the models.

Variable type	Variable	Type	Description (range/levels)
Attributes used to describe the choice tasks	Purchase price	Continuous	€10,000 (range BEV: 16 to 40) (range ICEV: 10 to 26)
	Fuel economy BEV	Continuous	Euros per 100 km (range BEV: 2 to 5) (range ICEV: 8 to 16)
	Driving range	Continuous	100 Km (range BEV: 1.5 to 4) (range ICEV: 4 to 12)
	Max distance between charging stations	Continuous	Km (range: 10 to 80)
	Free parking	Dummy	1: 3 hours or more 0: 1 hour
	Fast charging time	Dummy	1: 55 minutes 0: 25 minutes or 40 minutes
	Medium-small size car	Dummy	1: car brand Nissan or BMW 0: car brand Daimler, Renault, or Volkswagen
Socio-economic characteristics of the respondents	IT	Dummy	1: country of residence Italy 0: country of residence Slovenia
	Male	Dummy	1: male 0: female
	High family income	Dummy	1: family income > €70,000; 0: family income ≤ €70,000
	Experienced driving a BEV	Dummy	1: respondent experienced driving a BEV 0: otherwise
	Young	Dummy	1: respondent aged 18–34 0: otherwise
Measurement indicators: *Env_awareness*	Self-declared level of environmental concern	Ordinal (1–4)	1: highest 4: lowest
	Environmental association	Binary	1: Yes 0: No
Measurement indicators: *BEV_knowledge*	Self-assessed level of expertise with BEVs	Ordinal (1–7)	1: lowest 7: highest
	BEV driving experience	Binary	1: Yes 0: No

Slovenian and Italian respondents. Hence, we introduce country-specific attributes in both the utility functions (eq. (6) and (7)) and in the structural equations (eq. (3)). Individuals having lexicographic preferences have been excluded from the dataset. We tested all vehicle, infrastructural and policy attributes and many of the available socio-economic variables collected in the first part of the questionnaire. For the driving range attribute, we tested both a technology-specific linear attribute and a technology-nonspecific logarithmic specification,[3] opting for the latter since it resulted in a better overall fit of the model in terms of both the AIC and BIC criteria. Next, along the lines suggested by Schmid and Axhausen (2019), we made sure that all socioeconomic characteristics are specified in both the utility functions and the latent variable structural equations in order to disentangle the direct, indirect and total impact of the socio-economic characteristics.

Having tested and compared different softwares, we present in Table 3 the estimates generated by the Apollo package developed in R.[4] We tested different model specifications with an increasing level of complexity: a multinomial logit model, a random parameter logit model, a hybrid mixed logit model with only one latent variable, and a hybrid mixed logit model with both latent variables. In Table 3 we present the estimates of the best fitting model, that is the joint hybrid mixed logit model (HMXL) with two latent variables. The inclusion of both latent variables increased the goodness of fit of the model, proving that they help explaining the car choice process. We used a simultaneous approach for the estimation of the utility functions and of the structural equations (Bahamonde-Birke and de Dios Ortúzar, 2014). Table 3 comprises several parts. Part A reports the results of the discrete choice components of each model. Part B and part C describe the estimates of the measurement equations and structural equations of the latent variables $LV_{Env\_awareness}$ and $LV_{BEV\_knowledge}$. Part C also includes the estimated scale parameter. We tested whether it is statistically significantly different from one. Since we found that it is not (Student's *t*-test equal to 0.724), we could not reject the null hypothesis that the variance of the data collected from the Slovenian subsample is statistically different from the variance of the data collected from the Italian one. All the

[3] We thank an anonymous referee for suggesting the latter strategy.

[4] We initially estimated the model with Matlab using the code developed by Mikołaj Czajkowski and available at https://github.com/czaj/dce (last accessed on February 21st, 2019) under Creative Commons BY 4.0 license. We then used Biogeme and the code developed by Michel Bierlaire and available at https://biogeme.epfl.ch/index.html (last accessed on January 23rd, 2020). Finally, we used R and the code provided by Stephane Hess and David Palma, which is available at http://www.apollochoicemodelling.com/manual.html (last accessed on January 23rd, 2020) (Hess and Palma, 2019).

Table 3
Results of the HMXL.

	Italy Estimate (Std.err.)	Slovenia Estimate (Std.err.)
Part A: Vehicle, infrastructural and policy attributes		
ASC_{BEV}	1.548*** (0.157)	1.728*** (0.323)
Purchase price	−1.227*** (0.049)	−1.011*** (0.197)
SD_Purchase price	0.891*** (0.04)	0.788*** (0.157)
Ln(Driving range)	1.073*** (0.081)	1.597*** (0.301)
SD_Ln(Driving range)	0.741*** (0.051)	0.796*** (0.16)
Fuel economy	−0.048*** (0.007)	−0.117*** (0.024)
Max distance btw fast charging station	0 (0.001)	−0.004*** (0.001)
Free parking	0.262*** (0.063)	0.246*** (0.05)
Fast charging time	−0.039 (0.062)	−0.025 (0.065)
Medium-small size cars	0.183*** (0.039)	0.043 (0.033)
Socio-economic variables		
Male	−0.021 (0.111)	−0.441*** (0.125)
High income family	−0.478 (0.237)	−0.265 (0.272)
Young	0.135 (0.158)	−0.17 (0.134)
Part B: Latent variable Environmental awareness		
$\lambda_{Env\_awareness}$	−0.454*** (0.078)	−0.135** (0.067)
Measurement equation		
• $\gamma_{Env\_association}$	−0.776*** (0.168)	−1.39*** (0.482)
• τ_1	1.587*** (0.127)	2.714*** (0.428)
• $\gamma_{Env\_concern}$	1.011*** (0.202)	1.499*** (0.290)
• τ_1	−0.901*** (0.106)	−1.328*** (0.11)
• τ_2	2.341*** (0.148)	1.28*** (0.134)
• τ_3	4.662*** (0.242)	3.273*** (0.228)
Structural equation		
• α_Male	0.122 (0.126)	0.215** (0.103)
• α_High income family	−0.201 (0.262)	0.082 (0.417)
• α_Young	−0.076 (0.153)	0.247 (0.232)
Part C: Latent variable BEV knowledge		
$\lambda_{BEV\_knowledge}$	0.06 (0.062)	0.042 (0.056)
Measurement equation		
$\gamma_{Self-assessed\ BEV\ knowledge}$	1.386*** (0.183)	1.373*** (0.187)
• τ_1	−2.14*** (0.135)	−1.405*** (0.155)
• τ_2	−0.598*** (0.093)	0.42*** (0.129)
• τ_3	0.602*** (0.104)	1.782*** (0.169)
• τ_4	1.472*** (0.156)	2.557*** (0.202)
• τ_5	3.337*** (0.264)	4.165*** (0.278)
• τ_6	4.682*** (0.351)	5.399*** (0.327)
$\gamma_{BEV\ driving\ experience}$	1.498*** (0.267)	1.023*** (0.164)
• τ_1	2.965*** (0.317)	2.84*** (0.27)
Structural equation		
• α_Male	0.776*** (0.094)	1.708*** (0.175)
• α_Young	−0.097 (0.18)	0.399*** (0.12)
Scale parameter		1.075[a] (0.212)
Part D: Diagnostics statistics		
Number of individuals		1,739
Number of parameters		71
Number of observations		20,868
LL(start)		−18,102
LL(final, choice)		−11,765
AIC		36,277
BIC		36,841

[a] The p-value of the scale factor is computed with respect to a value of 1.

country-specific coefficients we estimated were significantly different between the two countries, thus we did not specify any generic parameter. Part D contains the diagnostic statistics.

Part A in Table 3 reports the country-specific parameters jointly estimated to describe the respondents' preferences for the vehicle, the infrastructural and the policy attributes. Both Asc_{BEV} are positive and statistically significant, implying that, *ceteris paribus* (net of all attributes and socio-economic interactions used in the specification), the utility associated with the BEV is higher than that associated with the ICEV. In order to capture the preferences heterogeneity, we specified all the parameters as normally distributed, discovering that only the parameters associated with purchase price and that of the logarithm of the driving range have a statistically significant standard deviation. Comparing the estimates obtained for *Purchase price* and *Driving range* we find that Italian respondents are more price sensitive, while Slovenians are more sensitive with respect to driving range. The former cannot be easily explained since the average family income in Italy is higher than in Slovenia, while the driving range sensitivity might be explained with the longer average distances travelled by Slovenians. *Fuel economy*, measured as the petrol\electricity cost for driving 100 km, is also highly significant and has the expected negative sign, with Slovenians being much more sensitive to this technical attribute than Italians. This result might be due to the lower average disposable income of Slovenians and the longer distances they travel. *Max distance btw charging stations* is not statistically significant for Italians. The estimates we have found for Slovenians, instead, are negative and statistically significant. This might be due to the higher density of the charging infrastructure in Slovenia and the fact that 75% of the respondents live close to a fast charging stations. *Free parking*, a dummy variable being equal to 1 when a minimum of 3 parking hours are granted to BEV owners, has a positive and statistically significant parameter for both subsamples. According to our results, thus, parking policies would help increasing BEVs uptake both in Italy and in Slovenia. The estimates of *Fast charging time* equal or longer than 55 minutes, instead, are not statistically significant. Finally, we estimated the preferences for *Medium-small size cars*, a dummy variable equal to 1 for medium-small size vehicles (BMW i3\Series 1, Nissan Leaf\Qashqai) and 0 for small size ones (Dailmer e-Smart \Smart, Renault Zoe\Clio and Volkswagen e-Golf\Golf). The estimates we find for both countries are positive, however they are statistically significant only for Italians.

As anticipated above, in order to distinguish between the direct impacts that the socio-economic characteristics of the respondents have on the choice between BEVs and ICEVs and the indirect impacts they produce via the latent variables, we specified some interaction terms between few socio-economic variables (i.e., gender, income, and age) and the alternative specific constants ASC_{BEV}. We find that only gender influences the utility associated with choosing a BEV. The interaction term is negative and statistically significant for Slovenians, meaning that, *ceteris paribus*, females get a higher utility from BEVs compared to males. This effect, however, is not statistically significant for Italians. Moreover, we do not find any statistically significant income effect for Italians nor for Slovenians. Surprisingly, age, more specifically being aged 18 to 34, does not influence the utility of buying a BEV, independently of the respondent nationality.

Part B and Part C of Table 3 report the estimates of the structural and measurement equations of the latent variables *Environmental awareness* and *BEV knowledge*, respectively. Regarding the former, the parameters $\lambda_{Env\_awareness}$ are statistically significant for both countries and indicate that a higher environmental awareness is associated with a higher utility derived from purchasing a BEV. This effect is much larger for the Italian subsample most probably because Italian cities are more polluted than Slovenian ones and the sensitivity towards environmental problems is stronger in Italy. In the measurement equations, the parameters $\gamma_{Env\_association}$ and $\gamma_{Env\_concern}$ for Slovenians are higher, in absolute values, than those estimated for Italians. In both cases, however, the link between the two indicators and the latent variable is highly significant. For both countries the parameters $\lambda_{Env\_awareness}$ and $\gamma_{Env\_association}$ are negative, meaning that respondents who are not members of an environmental association have a relatively lower concern for the environment. The parameters $\gamma_{Env\_concern}$ are positive and statistically significant, consistently with our expectations, since we coded the indicator 1 when the respondent has a high environmental concern and 4 when the respondent manifests low environmental concern. The structural equation indicates that only gender matters for the Slovenian subsample: Slovenian males have a lower environmental awareness than females. Neither income nor age are statistically significant, meaning that they are not good predictors of the latent variable *Environmental awareness*. Compared with the previous literature that has discussed the role played by environmental awareness on the intention to buy a BEV, women's higher environmental sensitivity is a new result. In fact, several authors do not report gender as a relevant socio-demographic characteristic with regards to environmental awareness (Graham-Rowe et al., 2012; Axsen and Kurani, 2013; Axsen et al., 2016; Quak et al., 2016; Hackbarth and Madlener, 2016; Soto et al., 2018a; Kormos et al., 2019; Orlov and Kallbekken, 2019).

Turning to the latent variable *BEV_knowledge*, we find that for both countries the parameters $\lambda_{BEV\_knowledge}$ are not statistically significant, that is we do not find statistical evidence that there is a relationship between higher BEV knowledge and higher utility derived from purchasing a BEV. However, for both countries both measurement indicators carry the expected sign and are statistically significant. The structural equations indicate that for both subsamples men have a higher knowledge of BEVs than women and this relationship is stronger for Slovenians. Being aged 18 to 34, instead, is significantly related to a higher knowledge of BEVs only for Slovenians.

As illustrated by Schmid and Axhausen (2019), while in the random parameter logit model we measure the direct effects that the socio-economic characteristics have on utility, in the hybrid mixed choice model we estimate also how the socio-economic characteristics influence the utility through the impact they have on the latent variables (Fig. 2). Applying the delta method, we are then able

Table 4
Direct, indirect and total effects of country-specific socio-economic characteristics on the utility derived from purchasing a BEV (ASC_{BEV}) in the HMXL model.

Socio-economic characteristics	Direct Effect Coeff. (SE)	Indirect Effect LV *Env_awareness* Coeff. (SE)	Indirect Effect LV *BEV_knowledge* Coeff. (SE)	Total Effect Coeff. (SE)
Male $_{IT}$	−0.021 (0.111)	−0.096 (0.086)	0.009 (0.038)	−0.072 (0.084)
Male $_{SI}$	−0.441*** (0.125)	−0.029 (0.022)	0.057 (0.076)	−0.311*** (0.076)
High income family $_{IT}$	−0.478 (0.295)	0.116 (0.13)		−0.361* (0.191)
High income family $_{SI}$	−0.265 (0.272)	−0.017 (0.039)		−0.202 (0.327)
Young $_{IT}$	0.135 (0.158)	0.036 (0.167)	0 (0.003)	0.157 (0.139)
Young $_{SI}$	−0.17 (0.134)	−0.025 (0.025)	0.017 (0.023)	−0.116 (0.138)

to decompose the total effect of the socio-economic characteristics into their direct and indirect components (Table 4).

We find that, independently from the nationality of the respondents and from the latent variable analyzed, the indirect effects of the socio-economic characteristics are not statistically significant. Only the total effect of gender is statistically significant, but this is mainly due to its direct effect on the ASC_{BEV} and holds true only for Slovenians.

6. Discussion and conclusions

Italy and Slovenia are neighboring countries that share many similarities but have also some differences. In terms of BEV uptake, their rate of adoption is certainly not comparable with that of the Northern European countries, whereas it is similar to that of other Southern and Eastern European countries. Thanks to an INTERREG research project, we were able to perform a survey on a significant number of respondents (N = 996 for Italy and N = 938 for Slovenia) and to analyze their answers to a stated-choice experiment. We estimated several model specifications of the discrete choice logit modelling family. This paper reports the results of a joint hybrid mixed logit model that takes into account vehicle, infrastructure and both policy and attitudinal variables, together with the most common socio-economic characteristics. Specifically, we focused on the role played by environmental awareness and BEV knowledge as potential co-determinants of the respondents stated choices.

The main findings are the following. Respondents of both countries have, *ceteris paribus*, a higher utility for BEVs than for ICEVs. As for the vehicle attributes, in line with most of the previous literature, we confirm that purchase price and driving range play a crucial role in consumers' decisions in both countries. Comparing the two countries, price sensitivity is relatively stronger in Italy than in Slovenia. This result cannot be explained on the basis of differences in the average income, because Italy is slightly richer than Slovenia, judging both from the national statistics and from the answers provided by our respondents. A reason might be that the purchase price differential between BEVs and conventional cars at the time of the survey (2018) was extremely high (about 10,000 euros) and the Italian government did not provide any purchase subsidy. More recently, policy makers in both countries perceived the importance associated to purchase price. Italy has introduced starting from April 2019 the so called "Ecobonus", a purchase subsidy which finances up to €6,000 the purchase of a new car whose CO_2 emissions are lower than 20 g/km.[5] Starting from August 2020 the subsidy has been further increased up to €8,000.[6] Slovenia, instead, had put in place such a measure before 2019[7] (Knez and Obrecht, 2017).

Although Italy has a larger geographical size, driving range and fuel economy sensitivity are statistically significant for both countries but are higher for Slovenians than for Italians, possibly because the percentage of respondents driving more than 20 thousand km per year is higher for the Slovenian subsample. The density of the fast charging network is significant, instead, only for Slovenians. The result found for Italians, however, is consistent with Hardman et al. (2018) according to which the most important location for charging is at home, followed by work and, then, by public locations.

Differently from the empirical evidence reported by several previous studies, in our sample charging time does not play a role in shaping the respondents' stated choices. Our interpretation is not that this feature is not important, but that our sample failed to perceive it as such. A possible explanation is the immaturity of the consumers' experience with BEVs in both countries. In fact, although the respondents claimed on average to have a moderate knowledge of BEVs, less than 20% had actually driven them. A further explanation is that since most of the respondents (93–94%) travel less than 10 times per year more than 400 km roundtrip, and more than 70% of them own a garage, they believe that they would rely on home charging and are less sensitive to the time required to recharge the battery.

The respondents of both countries attribute a significant importance to free parking as a factor influencing the purchase of a BEV, however, this policy is effective only if at least 3 hours of free parking are granted.

We confirm that the hybrid model specification improves the understanding of the choice process. We tested the impact of two latent variables, *Environmental awareness* and *BEV knowledge*, and we find that only the former has a statistically significant positive impact on BEV choice. This is in line with most of the previous literature, as illustrated in the "Related literature" Section. Our estimates show that the socio-economic characteristics we have analyzed do not explain the environmental attitude, except for gender that plays a role but only for the Slovenian subsample. Slovenian women, in fact, are more sensitive than men, as already detected by the direct effect of gender on the ASC_{BEV}. Surprisingly, younger respondents are not more sensitive than older ones about the environment. The relatively higher concern for the environment of the Italian respondents (especially with respect to the place where they live) is most likely connected with the worse air pollution levels of several Italian cities and towns (located both in the Northern regions known as the Pianura Padana as in the Southern ones) relative to the Slovenian ones.

[5] Purchasers are entitled to benefit from the maximum amount of the subsidy when the purchase of a new car, with a price lower than €50,000, is associated to the scrapping of an old one. Detailed information on the policy is provided at the following URL: https://ecobonus.mise.gov.it/.

[6] https://ecobonus.mise.gov.it/news/simple-news-folder/ecobonus—al-via-domani-i-nuovi-contributi-per-i-veicoli-a-basse-emissioni.

[7] The enacted polices included 1) a loan scheme to buy an electric vehicle whose price does not exceed €40,000 and the level of CO_2 emissions is lower than 120 g/km, 2) a decreasing (increasing) tax rate for decreasing (increasing) levels of CO_2 emissions, 3) financial subsidies, based on a yearly allowance of €500,000 made available by the government. The amount of the subsidies varies according to the type and class of the vehicle and ranges from €1000 to €5000, values that rose from 2016 reaching €7500 for battery electric vehicles and €3500 for plug-in electric vehicles. A further policy measure included the promotion of electric vehicle to the public with the aim of building familiarity with it (see Knez and Obrecht, 2017, p. 155 for a detailed indication on the year each measure was enacted). In 2017, the ministry for infrastructures of the Republic of Slovenia adopted a new market development strategy for the establishment of appropriate infrastructures related to alternative fuels in the transport sector. The strategy indicates that after the year 2030 the first registration of cars with a carbon footprint greater than 50g of CO_2 per km will no longer be permitted.

We do not find, instead, a positive association between the latent variable *BEV knowledge* and the utility derived from buying a BEV. As documented in the "Related literature" Section, this finding is not new. Knowing a BEV or having driven a BEV in the past does not necessarily imply a more positive evaluation, especially given the still limited driving range in some of the affordable BEVs available in the market (recall that our alternatives included only segments A to C car models). Our finding, hence, does not support the view that exposing the drivers to more information or direct experience (via renting, sharing, driving trails, etc.) would lead to a higher BEV uptake as argued by some previous papers.

In the case of our respondents and on the basis of our estimates, the most promising policies to increase the BEVs uptake are purchase price subsidies and free parking, while the most important technical improvement is the driving range extension.

Although we have carefully carried out the stated choice experiment, our research effort has several caveats and limitations that must be acknowledged. The first one concerns the questionnaire and its administration. As described above, we used a CAWI interview that has the advantage of being cheaper and faster to be administered to large samples than a CAPI (Computer Assisted Personal Interview) or a CATI (Computer Assisted Telephone Interview). A disadvantage is that it requires all respondents to have an email account and a basic knowledge of computers to complete correctly the questionnaire. Moreover, since there is no personal interaction with an interviewer, no information or clarification on the choices and attributes can be provided and no data can be collected on the time, attention and effort that respondents put into fulfilling their task. Since BEVs are still controversial regarding their environmental impact and safety features, the choices made by the respondents reflect their own convictions which can be wrong, immature or unstable.[8] In order to keep the interview short (a 5-minute interview is commonly suggested), we decided not to provide factual information on BEVs and their properties. The reader should be aware that different choices on how to set up the questionnaire and administer it might have let to different results.

As mentioned above, the selection of the attributes to be included in the stated choice experiments is a critical choice for any stated preference study. The topic is even more troublesome in a CAWI interview. Although we restricted ourselves to 7 attributes, only 5 of them (brand\model type, purchase price, cost of fuel or electricity needed to travel 100 km, driving range with a full tank\charge, number of free parking hours for urban parking if driving an electric car) proved statistically significant for both subsamples. Our interpretation is that these are the most important ones for our respondents, but it does not imply that the others (time needed to fast charge 80% the battery and maximum distance in km between fast charging stations) are not relevant for the BEVs uptake. Note also that the attributes that are not statistically significant are BEV-specific and were presented to the respondents in the bottom part of the scenarios. Further research is certainly needed to test the impact that these methodological features had on our results, along the lines suggested, among others, by Hensher (2006).

The paper attempted to explore how the latent variables *Environmental awareness* and *BEV knowledge* influence the stated choices. Although we obtained some interesting results, it must be recognized that several improvements are needed. First of all, many more items could and should be used to identify the many facets of an attitude. As underlined by Borriello et al. (2019), psychologists use numerous items having a different valence (from extreme negative to extreme positive) to characterize a latent construct, while transport choice analysts often restrict themselves to a more limited set of items, often direct ones and with either a positive or negative value only. The need to limit the survey time and not to overburden the respondent comes at a cost of potentially higher measuring error. In our specific case, improvements are certainly needed in the characterization of the *BEV knowledge* latent variable along the following lines: a) distinguish between subjective and objective knowledge; b) distinguish between the two main components of knowledge, e.g. third party information and direct experience; c) specify the various areas of knowledge, e.g. technical (performance, battery degradation, charging issues, etc.), economic (resale value, maintenance costs, electricity and charging cost), environmental (lifecycle global and local pollution) and policy related (monetary and regulatory incentives). A more complete characterization of the latent variable *BEV knowledge,* which we plan to carry out in future research, might help clarifying the relationship between knowledge and choice and identifying the levers that are available to spur BEVs uptake, with specific focus in the laggard countries like Italy and Slovenia. The *Environmental awareness* latent variable is less controversial and widely used in the transportation choice literature. We used two items to measure it: a local one (the environmental quality of the place where the respondent lives) and a general one (member of an environmental association or active engagement in an environmental association). However, more items would help obtaining a more precise definition of the degree of environmental awareness.

CRediT authorship contribution statement

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

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[8] We thank an anonymous referee for pointing this out.

Appendix

(See Table A1 and Table A2)

Table A1
Levels of purchase price, fuel economy and driving range by vehicle type for the Italian sample.

Brand	Price levels for BEVs (€1,000)	Price levels for petrol cars (€1,000)	Fuel economy for BEVs (Euro per 100 km)	Fuel economy for petrol cars (Euro per 100 km)	BEV driving range with full battery (100 km)	Petrol car driving range with full tank (100 km)
BMW	33; 37; 40	18; 22; 26	3; 4; 5	9; 13; 16	1.5; 2; 2.5	8; 10; 12
VW	33; 37; 40	14; 18; 22	3; 4; 5	9; 13; 16	3; 3.5; 4	8; 10; 12
Renault	24; 28; 33	10; 14; 18	3; 4; 5	9; 13; 16	3; 3.5; 4	8; 10; 12
Nissan	24; 28; 33	14; 18; 22	3; 4; 5	9; 13; 16	3; 3.5; 4	8; 10; 12
Daimler	16; 20; 24	10; 14; 18	3; 4; 5	9; 13; 16	1.5; 2; 2.5	4; 6; 8

Table A2
Levels of purchase price, fuel economy and driving range by vehicle type for the Slovenian sample.

Brand	Price levels for BEVs (€1,000)	Price levels for petrol cars (€1,000)	Fuel economy for BEVs (Euro per 100 km)	Fuel economy for petrol cars (Euro per 100 km)	BEV driving range with full battery (100 km)	Petrol car driving range with full tank (100 km)
BMW	30; 33; 37	18; 22; 26	2; 3; 4	8; 11; 14	1.5; 2; 2.5	8; 10; 12
VW	33; 37; 40	14; 18; 22	2; 3; 4	8; 11; 14	3; 3.5; 4	8; 10; 12
Renault	20; 24; 28	10; 14; 18	2; 3; 4	8; 11; 14	3; 3.5; 4	8; 10; 12
Nissan	28; 33; 37	14; 18; 22	2; 3; 4	8; 11; 14	3; 3.5; 4	8; 10; 12
Daimler	16; 20; 24	10; 14; 18	2; 3; 4	8; 11; 14	1.5; 2; 2.5	4; 6; 8

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