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Fiscal policies and car choices in Italy and Norway: A scenario analysis based on a stated-preference survey

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ABSTRACT

Norwegian and Italian car drivers make very different car choices. This paper investigates the influence of fiscal policies on car buyers' choices, using data collected from a stated preference survey conducted in 2021. After estimating a joint random parameter logit model, we simulated the market shares of five car powertrains under three scenarios: "Italian car buyers face the same net purchase car prices and fuel\electricity costs as the Norwegian car drivers and vice versa", "Italy adopts the Norwegian registration tax", and "Both Italy and Norway adopt a social cost internalizing registration tax". The results indicate that Italian car users are reluctant to switch to battery electric cars (BEVs). They would choose BEVs more frequently in the three scenarios envisaged but without reaching the corresponding Norwegian levels. If Italy would adopt the Norwegian registration tax system, BEVs' market share would gain 5.4 percentage points relative to the baseline scenario, while under the social cost internalizing scenario, BEVs' market share would improve by 3.4 and PHEVs' one by 0.2 percentage points. On the contrary, Norwegians are BEV-oriented and would comparatively preserve a high BEV share. In the social cost internalization scenario, the BEV share relative to the baseline scenario would decrease by 7.2 percentage points, petrol cars would gain 1.2, HEVs 2.9, PHEVs 3.4, and diesel cars would lose 0.3 percentage points. In general, there seems to be a lock-in or path dependence effect that limits BEV penetration in Italy and prevents the decline of the BEV share in Norway.

1. Introduction

The reduction of the environmental impact of transport at local and global level is a goal pursued by all countries using a variety of policies conventionally classified as command-and-control (regulatory) or fiscal policies.

An example of the former are the zero emission vehicle (ZEV) mandates, pioneered by California in 1990 and subsequently adopted in other "ZEV States" in the U.S., in Canada and in China, that directly require auto manufacturers to sell a minimum amount of ZEVs each year. The European Union followed a slightly different path. Since 2009, it introduced obligatory corporate average CO_2 emissions' limits on new passenger cars and light commercial vehicles registered in the European Union and EEA member states. Other forms of command-and-control policies are fuel content regulation, vehicle emissions standards, rules that ensure that car buyers are informed on the fuel-efficiency characteristics of the cars they buy or lease, or, more recently, internal combustion vehicle phase-out legislation. Important pros of the command-and-control policies are that they can be enacted at international level and that they do not require public funds.

Fiscal policies aim at influencing consumer's decisions by altering the relative prices\costs. In the context of passenger car acquisition and use, fiscal policies might take many forms such as purchase taxes, registration taxes, company car taxes, annual road taxes, fuel taxes, and parking taxes. Their ability to reduce CO_2 and other pollutant emissions or improve fuel efficiency has been theoretically and empirically analyzed in many papers. Some of the empirical papers are country-specific (e.g. Chugh & Cropper, 2017); other papers performed a cross-country analysis (Gerlagh et al., 2018; Dineen et al., 2018).

Fiscal policies have been evaluated according to different criteria: effectiveness, economic efficiency, administrative feasibility, equity, and political acceptability (Sykes & Axsen, 2017; Lam & Mercure, 2021). Their performance has been assessed with a variety of techniques: difference in differences approach (e.g., Ciccone, 2018),

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regression models (Ciccone & Soldani, 2021), technology adoption simulation models (e.g., Sykes & Axsen, 2017; Lam & Mercure, 2021), agent-based models (Sen et al., 2017) or macroeconomic general equilibrium models (e.g., Shafiei et al., 2019). Such methodologies have three main pros: i) they analyze the causal effect between the policy actions and the outcome variables, net of time trends and market seasonality, and controlling for exogenous factors (Ciccone, 2018); ii) they can be used to carry out either ex-ante (Sykes & Axsen, 2017) or ex-post analyses (Ciccone, 2018; Ciccone & Soldani, 2021); iii) they can incorporate supply-side elements (Shafiei et al., 2019; Sen et al., 2017). A weak point is that, apart from the agent-based models, they are based on aggregate data and, hence, rely on the representative agent assumption.

A quite different tradition, to which this paper belongs, employs disaggregate data analyzed via discrete choice models, theoretically based on the random utility theory (McFadden, 1986; Ben-Akiva et al., 1999). Such a long-standing tradition dates back to the studies on vehicle choice by Lave & Train (1979), Manski & Sherman (1980), Wright & Train (1987), and Berkovec & Rust (1985). Most studies focus on the determinants of car choice such as the vehicle attributes, the socio-economic characteristics of car buyers or their latent attitudes (environmental concern, interest towards technology, moral obligation, etc.). For a review, see Liao et al. (2017), Coffman et al. (2017), Greene et al. (2018), Rotaris et al. (2021). A smaller number of studies used the discrete choice model estimates to evaluate policy scenarios. Among these, Bunch et al. (1993) evaluated alternative clean-fuel vehicles and fuel supply scenarios in the USA. Brownstone et al. (2000) analyzed the impact on the scenario forecasts of different model specifications (standard logit, mixed logit, revealed/stated preference logit). Mabit (2014) estimated the impact on purchasing behavior of the Danish 2007 vehicle tax reform. Tanaka et al. (2014) estimated battery electric vehicle (BEV) and plug-in hybrid electric vehicle (PHEV) market shares under several innovation scenarios, contrasting U.S. with Japan. Valeri & Danielis (2015) evaluated the impact of pricing policies and technological improvements in Italy. Hackbarth & Madlener (2016) analyzed which vehicle attribute could increase the demand for alternative fuel vehicles cost-effectively in Germany, via private provision or via governmental subsidies. Cherchi (2017) analyzed the role of parking policies (both parking price and slots reserved for electric vehicles (EVs)) in boosting the demand for EVs in Denmark in the presence of informational and normative conformity.

Following this last stream of literature, this paper presents a scenario analysis based on a discrete choice model estimated using stated preference (SP) data concerning Italy and Norway. We thought it is interesting to compare these two countries since their respective car buyers make very different car choices. Norway is a leading nation in terms of BEVs uptake, Italy is lagging behind.

In Norway, BEVs and PHEVs[1] dominated the car market in 2021, with a share of 64.5% and 21.7%, respectively, with the remaining powertrains playing a marginal role. On the contrary, in Italy, petrol, diesel and hybrid cars (HEV) made up the large majority (81.3% of the total registrations) of the Italian passenger car market. Other fossil fuel-based cars, such as Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG), had a market share of 7.3% and 2.1%, respectively.

Specifically, we estimated a joint random parameter logit model for the two countries, based on data collected via a web-based questionnaire, including stated preference scenarios among five cars with different powertrains (petrol, diesel, hybrid, plug-in hybrid and battery electric). Each car was characterized by three attributes: net purchase price, driving range and fuel\electricity costs. A large variety of socio-economic and infrastructural variables was also considered. Such a model allowed us to compare the preference structures between the two countries.

[1] Throughout the paper, we will use the acronym EV to mean both BEVs and PHEVs.

To the best of our knowledge, a limited number of papers carried out similar comparisons. Tanaka et al. (2014) compared the consumers' willingness to pay (WTP) for BEVs and PHEVs in Japan and four U.S. states, two countries with similar wealth but different culture when EV uptake was at the early stages. Helveston et al. (2015) compared U.S. and China; in this case two countries different both in wealth and in culture. Noel et al. (2019) compared stated car drivers' choices in five very similar Nordic countries: Denmark, Finland, Iceland, Norway and Sweden. Rotaris et al. (2021) compared preferences and attitudes in Italy and Slovenia, again similar in terms of wealth and both at the early stages of EV uptake. Only one of them (Tanaka et al., 2014), however, used the estimated choice model to carry out a scenario analysis to check how similar policies impact differently consumers' choices in the two countries.

The study presented in this paper considered three scenarios: "S.1 - Italian car buyers face the same net purchase car prices and fuel\electricity costs as the Norwegian car drivers and vice versa", "S.2 – Italy adopts the Norwegian registration tax", and "S.3 – Both Italy and Norway adopt a social cost internalizing registration tax". We believe that the results we obtain could guide policy makers to adjust their decisions to meet their goals. In the case of Italy, the goal could be to accelerate the uptake of more environmentally friendly cars and meet the local and global environmental challenges. Italy is, in fact, characterized by high air pollution levels in the major urban areas (Rotaris et al., 2021) and struggles to meet the CO_2 reduction goals set at European level. In the case of Norway, the goal could be to keep the momentum and continue increasing the BEV share in the national fleet, while at the same time maintaining under control the public budget dedicated to passenger cars and avoiding an increase in number of cars in the population.

The paper is structured as follows. Section 2 illustrates and compares the car fiscal policies in the two countries. Section 3 illustrates the modeling framework. Section 4 describes the survey, the questionnaire, the sample and discusses the econometric results. Section 5 defines the scenarios and illustrates their impact on car choice. Section 6 summarizes the main results, draws some policy implications and discusses the main limitations of the study.

2. Car tax policies in Italy and Norway

2.1. Italian car tax policies

As most countries, Italy relies on a complex combination of car taxes, which can be distinguished into car acquisition taxes (or registration taxes) and ownership (or circulation) taxes. In addition, Italian car users are affected by fuel excise taxes, parking fees, and highway tolls. Acquisition and circulation taxes in Italy are defined and administered at provincial level, hence, they can be differentiated by place of residence. Fuel excise taxes, on the contrary, are set at national level.

One-off vehicle registration taxes comprise two components: a fixed component, equal to €151 set at national level, and a variable component (termed "Imposta Provinciale di Trascrizione", provincial transcription tax (IPT)), set at provincial level. The variable part ranges between €3.51 and €4.56 per kW of engine displacement exceeding 53 kW. For "ecological cars" (defined as PHEV, BEV, natural gas, hydrogen and for some province also HEV), the variable part is either reduced or increased, depending on the Province.

In addition to the registration tax, Italian car drivers might obtain a car purchase subsidy. The ones in force in the year 2021 are summarized in Table 1. They illustrate the compromise between the governing parties and, as it can be noted, they aim at two goals: fostering the uptake of less CO_2 intensive cars and renovating the car fleet. The total budget devoted to car purchase subsidies for the year 2021 was equal to 200 million euro, unequally subdivided by emission category. During the year 2021, the allocated funds were quickly used up, especially for the cars belonging to the 61–135 g CO_2/km category. More recently (March 2022), the car purchase subsidies have been revised to €3000

Table 1
Italian 2021 car purchase subsidies.

Cars emissions	Amount	Sources
0-20 g CO_2/km		
– without scrapping	€6500	€5500 State bonus + €1000 discount by the car dealer
– with scrapping*	€10,000	€8000 State bonus + €2000 discount by the car dealer
21–60 g CO_2/km		
– without scrapping	€4500	€2500 State bonus + €1000 discount by the car dealer
– with scrapping	€6500	€4500 State bonus + €2000 discount by the car dealer
61–135 g CO_2/km		
– without scrapping	€1750	€750 State bonus + €1000 discount by the car dealer
– with scrapping	€3500	€2000 State bonus + €2000 discount by the car dealer

*The scrapped cars should belong to the Euro categories 1, 2, 3, 4.

(€5000), €2000 (€4000), €0 (€2000) for each emission category, with the addition of a maximum car price (€35,000; €45,000; €35,000) to be eligible for the subsidy.

To illustrate the impact of the registration taxes and purchase subsidies, we have calculated the average net purchase price of the 10 best-selling cars in Italy for each powertrain (petrol (PV), diesel (DV), HEV, PHEV and BEV). The net purchase price (NPP) is the sum of the 2021 MSRP (Manufacturers' Suggested Retail Price, or factory gate vehicle price; the MSRP is derived from the car manufacturers or car magazines' websites), the registration tax (estimated based on the kW, assuming as residency the Province of Trieste) and the purchase subsidy (assuming the subsidy without scrapping, i.e. its minimum level). The results are reported in Table 2. It turns out that in 2021 all cars were paid by car buyers less than what officially suggested by car manufacturers. Note that the values are most likely an overestimation of the actual price paid since they do not account for the discount commonly granted by the car dealers. However, they serve our purpose to compare the impact of the fiscal policies on net purchase cost for different powertrains. The variable component of the registration tax penalizes PHEVs and BEVs since they have higher kW values, but subsidies associated to CO_2 emissions more than compensate such an effect so that they increase their relative competitiveness.

The above discussion is valid for private passenger cars. Company cars are subject to a different regulation. Depending on the type of company and the use of the car, they might be eligible for a reduction of the 22% VAT rate. The amount of the reduction depends also from the CO_2 emissions of the car. They were eligible for subsidies under the 2021 regulation, but not under the 2022 regulation (up to April 2022), unless bought by carsharing companies. Since company cars make up a large part of the car market (almost 49.1%), the new regulation had been heavily criticized by EV supporters.

Regarding the annual circulation tax, the approach is similar to the acquisition tax. The circulation tax is based on the engine displacement (kW), hence, it does not favor EVs since BEVs and PHEVs tend to have higher kW values. Comparing among the 10 best-selling cars for each powertrain, in 2021 the average kW values were the following: PV 96, DV 103, HEV 104, PHEV 190, and BEV 147. However, BEVs enjoy a reduction of the annual circulation tax varying by Region; 18 out of 20 regions grant a 5-year exemption of the circulation tax, and from the 6th year they pay 25% of the amount due. Two regions (Lombardy and Piedmont) grant full exemption for the car lifetime.

Table 2
Italian 2021 NPP by powertrain. All values are in euro.

	MSRP (incl. 22% VAT)	Registr. Tax (fixed)	Registr. Tax (variable)	Subsidy*	NPP 2021	NPP2021/MSRP
PV	19,265	151	259	1295	18,380	95%
DV	29,641	151	345	1393	28,744	97%
HEV	19,238	151	235	1673	17,952	93%
PHEV	43,037	151	527	4500	39,215	91%
BEV	30,574	151	403	6500	24,628	81%

*Assuming the subsidy is without scrapping.

2.2. Norwegian car tax policies

The backbone of Norwegian fiscal car acquisition policy is the Vehicle Registration Tax (VRT), radically modified in 2007, switching the focus from the engine size to the tare weight, CO_2 emissions, NOx emissions and scrapping cost. In contrast with the Italian approach, no direct subsidies are granted when buying a car. Those on tare weight and CO_2 emissions are progressive taxes with the structure illustrated in Table 3.

The NOx fee is a proportional tax set to NOK 78.14 per mg/km, while the scrapping tax is set to NOK 2400 per car. Imported cars of the following powertrains, PV, DV and HEV, for private use pay all four taxes in full. PHEVs pay a discounted tare weight, accounting for the fact that part of the weight is due to the batteries and the electric motor. A maximum 15% discount of the tare weight is applied. The discount is proportionally reduced if the distance covered in electric mode only is lower than 100 km. BEVs are subject only to the scrapping tax. Hence, they are exempted not only from tare weight, CO_2 emissions, NOx emissions tax (reasonably from the last two, since only the tail-pipe emissions are considered), but also from the 25% VAT imposed on cars. For a critical discussion of the Norwegian registration tax see Steinsland et al. (2016) and Fridstrøm & Østli (2017).

In Norway, the annual road tax has been replaced with a motor insurance tax. Up to March 1st, 2022, it was slightly differentiated between conventional and electric cars (NOK 3066 vs NOK 2135 per year), but the differentiation was recently eliminated (https://www.tff.no/en/kjoretoy/trafikkforsikringsavgift/).

Table 3
Norwegian tare weight and CO_2 emission tax.

Tare weight Tax (NOK/kg)	NOK	CO_2 Tax[6] (g/km)	NOK
0–500 kg	0	0–87 g	0
501–1200 kg	27.15	88–118 g	1095.4
1201–1400 kg	67.68	119–156 g	1227.52
1401–1500 kg	211.49	157–226 g	2382.68
>1500 kg	245.97	>226 g	3800.83
		50–87 g	−831.37
		<50 g	−978.12

Source: https://www.smartepenger.no/bilokonomi/354-engangsavgifter-pa-bil.

[6]The CO_2 tax is an environmental tax. The Norwegian Tax Administration generally uses the vehicle's CO_2 emissions as basis when calculating the one-off registration tax. When approving used imported vehicles, the Norwegian Public Roads Administration will register both cylinder volume and CO_2 emissions if the information is available. If the Norwegian Public Roads Administration has registered CO_2 emissions, this figure must be used when calculating the taxes.

Table 4
Net purchase price structure of 5 car models in Italy.

	VW Golf*	VW T-ROC**	Toyota RAV4	Toyota RAV4	Tesla Model 3
Powertrain	PV	DV	HEV	PHEV	BEV
MSRP *ex-fabrica* (€)	24,426	30,943	29,836	39,754	45,074
VAT 22% (€)	5374	6807	6564	8746	9916
Subsidy without scrapping (2021) (€)	1750	1750	1750	4500	6000
Variable Registration Tax (IPT) (€)	341	465	552	947	1087
Fixed Registration Tax (€)	151	151	151	151	151
Net Purchase Price (€)	28,542	36,616	35,353	45,098	50,228
Net Purchase Price/MSRP before VAT	1.17	1.18	1.18	1.13	1.11
MSRP *ex-fabrica* Index (BEV = 100)	54	69	66	88	100
Net Purchase Price Index (BEV = 100)	57	73	70	90	100

*VW Golf Life 1.0 110 hk eTSI 7-trinns DSG; **VW T-ROC 2.0 150 HK TDI SCR DSG 4MOTION.

2.3. *The impact of fiscal policies on the net purchase price*

In order to appreciate the difference between the Italian and the Norwegian car tax system with reference to the registration tax, we have selected 5 car models with different powertrains: VW Golf (PV); VW T-ROC (DV); Toyota RAV4 (HEV); Toyota RAV4 (PHEV); Tesla Model 3 (BEV). Their technical characteristics are reported in the supplementary material (SM 1.0). We evaluated their NPP by applying the Italian and the Norwegian national car tax\subsidy policies. Hence, the NPP incorporates the impact of the registration taxes and subsidies.

As it can be seen from Table 4, in Italy the relative NPP across powertrains is not significantly altered by the car fiscal system. Since the 22% VAT is levied on all cars, the ratio between the MSRP (before VAT) suggested by the car manufacturers and the final NPP ranges between 11% and 18%. Consequently, the relative competitiveness among powertrains is not significantly affected. Indexed relative to Tesla Model 3 (Tesla model 3 = 100), the last two rows of Table 4 show that the VW Golf loses 3 points (i.e., from 54 to 57), the VW T-ROC 4 points, the Toyota RAV4 HEV 3 points and the Toyota RAV4 PHEV 2 points.

In Norway, instead, the impact is much higher and more differentiated among powertrains, ranging from 1% to 67% (Table 5). Indexed relative to Tesla Model 3, the last two rows of Table 5 indicate that the VW Golf loses 36 points (i.e., from being 14% cheaper to being more expensive than the Tesla Model 3; i.e., from 86 to 122) and the VW T-ROC loses 59 points (from 120 to 179), respectively. The Toyota RAV4 HEV loses 46 points (from 68 to 114) and the Toyota RAV4 PHEV 31 points (from 81 to 112). In other words, the Norwegian car taxes influence the car market much more than the Italian one. Whether such government interventions are correct or not is, of course, open to discussion (Fridstrøm & Østli, 2017; Steinsland et al., 2016). Note also that the relative net purchase car prices in Norway are radically different from the Italian ones. In Norway, the cheapest car to buy for the consumer is the Tesla Model 3 (BEV), while in Italy the Tesla Model 3 is the most expensive.

In addition, BEVs uptake in Norway has been incentivized by a wide range of other financial and regulatory policies listed in Table 6, while in Italy BEVs enjoy free municipal parking and access to the limited traffic zone only in a few cities (importantly including Milan).

Table 6
Summary of the Norwegian BEV incentives (updated to April 2022).

Norway
No purchase/import taxes (1990-)
Exemption from 25% VAT on purchase (2001-)
No annual road tax (1996–2021). Reduced tax from 2021. Full tax from 2022.
No charges on toll roads or ferries (1997–2017).
Maximum 50% of the total amount on ferry fares for electric vehicles (2018-)
Maximum 50% of the total amount on toll roads (2019-)
Free municipal parking (1999–2017)
Parking fee for EVs was introduced locally with an upper limit of a maximum 50% of the full price (2018-)
Access to bus lanes (2005-). New rules allow local authorities to limit the access to only include EVs that carry one or more passengers (2016)
50% reduced company car tax (2000–2018). Company car tax reduction reduced to 40% (2018-) and 20% from 2022.
Exemption from 25% VAT on leasing (2015)
Fiscal compensation for the scrapping of fossil vans when converting to a zero-emission van (2018)

In the next sections of the paper, we will apply a discrete choice model to estimate the impact of the different fiscal policies on consumers' choices.

3. The modelling framework

In order to analyze consumers' choices between cars with different powertrains, we adopted the discrete choice modelling framework, where an individual n is assumed to consider the full set of J available alternatives for each choice task t and to indicate the powertrain chosen. The (relative) utility U_{njt} the individual receives from choosing alternative $j \in J$ in the choice task t is defined, for each country, as:

$$U_{njt} = ASC_{nj} + \beta_{nj}X_{njt} + \gamma_j Z_n + \varepsilon_{njt} = V_{njt} + \varepsilon_{njt} \quad (1)$$

Table 5
Net purchase price structure of 5 car models in Norway.

	VW Golf	VW T-ROC	Toyota RAV4	Toyota RAV4	Tesla Model 3
Powertrain	PV	DV	HEV	PHEV	BEV
MSRP *ex-fabrica* (NOK)	352,800	490,500	280,200	331,360	409,990
VAT 25% (NOK)	88,200	122,625	70,050	82,840	–
Tare weight tax (NOK)	20,832	50,518	91,815	101,684	–
NOx tax (NOK)	4,688	6,251	4,688	328	–
CO_2 tax (NOK)	32,862	67,100	19,717	−58,148	–
Scrap deposit tax (NOK)	2,400	2,400	2,400	2,400	2,400
Net Purchase Price (NOK)	501,783	739,394	468,871	460,464	412,390
Net Purchase Price/MSRP before VAT	1.42	1.51	1.67	1.39	1.01
MSRP *ex-fabrica* Index (BEV = 100)	86	120	68	81	100
Net Purchase Price Index (BEV = 100)	122	179	114	112	100

Source: estimated on March 2022, using https://www.skatteetaten.no/en/person/duties/cars-and-other-vehicles/importing/calculate/.

where ASC_{nj} represents the alternative-specific constants, X_{njt} includes all the attributes presented in the experiment and Z_n the socioeconomic characteristics, β_j and γ_j being parameters of fixed but unknown coefficients (Ben-Akiva & Lerman, 1985; Train, 2009). Assuming that the random part of the utility unknown to the analyst (ε_{njt}) is independent and identically distributed (IID) extreme value type 1, one obtains the conventional multinomial logit model. A more advanced specification is the random parameter logit (RPL) model that allows the researcher to account for random heterogeneity in preferences. It is assumed that the cumulative distribution function of β_n in the population is $F(\beta|\vartheta)$, which depends on parameters ϑ (e.g., mean and variance).

A final methodological point to be underlined is the following. In order to properly compare individual preferences across the two countries, one needs to estimate a joint model accounting for potential scale differences. A separate estimate for each country would not allow comparability of coefficients since the scale parameter, reflecting the unspecified attributes, might differ between the two countries (only parameter ratios could be compared). We opted for normalising the scale parameter with respect to Norway (Train, 2009; p. 25). Hence:

$$\begin{cases} U_{njt}^{NOR} = \left(ASC_{nj}^{NOR} + \beta_{nj}^{NOR} X_{njt} + \gamma_j^{NOR} Z_n + \varepsilon_{njt}\right) \\ U_{njt}^{IT} = \theta\left(ASC_{nj}^{IT} + \beta_{nj}^{IT} X_{njt} + \gamma_j^{IT} Z_n + \varepsilon_{njt}\right) \end{cases} \quad (2)$$

where $\theta = \theta^{IT}/\theta^{NOR} = \sigma^{NOR}/\sigma^{IT}$.

Nonetheless, the parameters of the Italian equation are over-specified since it is not possible to simultaneously estimate θ and the remaining parameters of the equation which are multiplied by θ (any product might result from an infinite combination of factors). At least one equation parameter for Italy should be set generic, that is, in common with the equation for Norway, so as 'to anchor' that parameter to the Norwegian dataset. A similar procedure has been applied by Jensen et al. (2013) to compare preferences and attitudes before and after experiencing an EV and by Noel et al. (2019) to compare preferences among Nordic countries.

4. Stated car choices in Italy and Norway: A field research

4.1. The survey

We collected data via a web-based survey, administered between November and December 2021 on a sample of Italian (N = 643) and Norwegian (N = 501) respondents using a CAWI (Computer Assisted Web Interviewing) questionnaire. We entrusted the data collection to two companies specialized in market surveys: SWG for the Italian sample and Norstat for the Norwegian one. The samples were randomly drawn from the two companies' communities so that only persons with a driving license were eligible to fill in the questionnaire. The questionnaire consisted into two main parts. The first part consisted of 10 hypothetical choice scenarios, as the one reported in Fig. 1.

$$\begin{cases} V_{n,\ PV}^{c} = ASC_{n,PV}^{c} + \beta_{n,Price} \cdot Price_{PV}^{c} + \beta_{n,Range}^{c} \cdot Range_{PV}^{c} + \beta_{n,F/E\ \text{costs}}^{c} \cdot F/E\ \text{costs}_{PV}^{c} \\ V_{n,\ DV}^{c} = ASC_{n,\ \ DV}^{c} + \beta_{n,Price} \cdot Price_{DV}^{c} + \beta_{n,Range}^{c} \cdot Range_{DV}^{c} + \beta_{n,F/E\ \text{costs}}^{c} \cdot F/E\ \text{costs}_{DV}^{c} \\ V_{n,\ HEV}^{c} = ASC_{n,HEV}^{c} + \beta_{n,Price} \cdot Price_{HEV}^{c} + \beta_{n,Range}^{c} \cdot Range_{HEV}^{c} + \beta_{n,F/E\ \text{costs}}^{c} \cdot F/E\ \text{costs}_{HEV}^{c} \\ V_{n,\ PHEV}^{c} = ASC_{n,PHEV}^{c} + \beta_{n,Price} \cdot Price_{PHEV}^{c} + \beta_{n,Range}^{c} \cdot Range_{PHEV}^{c} + \beta_{n,F/E\ \text{costs}}^{c} \cdot F/E\ \text{costs}_{PHEV}^{c} \\ V_{n,BEV}^{c} = ASC_{n,BEV}^{c} + \beta_{n,Price} \cdot Price_{BEV}^{c} + \beta_{n,RangeBEV}^{c} \cdot Range_{BEV}^{c} + \beta_{n,F/E\ \text{costs}}^{c} \cdot F/E\ \text{costs}_{BEV}^{c} + \\ \beta_{Age}^{c} \cdot \text{AgeClass}^{c} + \beta_{Gender}^{c} \cdot \text{Gender}^{c} + \beta_{Income}^{c} \cdot \text{Income}^{c} + \beta_{EVdensity}^{c} \cdot \text{EVdensity}^{c} + \beta_{BEVowner}^{c} \cdot \text{BEVowner}^{c} \end{cases} \quad (3)$$

For each choice task, respondents were asked to choose among five labelled alternatives: PV, DV, BEV, HEV, and PHEV. To facilitate comparability between the two countries, we opted, however, to focus only on the main powertrains on sale in Norway, thus disregarding the CNG and LPG powertrains which have a modest but not insignificant share in Italy.

Concerning the number of attributes used to characterize the hypothetical scenarios, our choice has been very conservative. We opted to restrict our selection to only three attributes, which on the basis of our experience (Danielis et al., 2020; Rotaris et al., 2021) and the literature (Liao et al., 2017; Coffman et al., 2017; Greene et al., 2018), have the strongest influence on car choice: net purchase price, fuel\electricity cost, and driving range. We explained respondents that net purchase price is to be intended as net of subsidies and including VAT and registration taxes. The attribute levels were selected factoring in the MSRP these car fiscal policy components to enhance the realism of the hypothetical choices (see SM 2.0). Fuel\electricity costs are the ones incurred to travel 100 km, while driving range is the maximum distance in km with a full tank\battery (tank plus battery for PHEVs[2]). They were calculated based on the variation of fuel economy within each powertrain.

In the second part of the questionnaire, we asked respondents socio-economic data, such as gender, age, educational level, occupation, household composition and income, house type (apartment vs. detached house), house ownership (for rent or as an owner), garage availability, home charging availability, and area of residence (urban, suburban, rural).

4.2. The sample

We were able to interview 1144 respondents, 501 Norwegians and 643 Italians. The absolute number is rather small in relation to similar car surveys. However, we devoted great care to achieve a good sample representativeness along various dimensions. The reference population are the driving license holders who have or plan to buy a passenger car. We checked the sample representativeness in the two countries by gender, age, occupation, income, household type, geographical area, educational attainment, type of housing, place of residency, and parking availability. The detailed results are reported in the SM 3.0, distinguishing between the Italian and the Norwegian sample. Overall, we consider satisfactory the sample representativeness along the above-described socio-economic dimensions except for two closely linked dimensions: an under-representation of the population with lower educational attainment (up to 7–8 years of education) and above 60 years of age.

[2] Admittedly, our choice is problematic since car buyer might value differently the range achievable in battery-only mode and that associated with the internal combustion engine. The issue might be considered negligible, however, when the battery-only range is limited.

	PETROL	DIESEL	BEV	HEV	PHEV
Price (net of taxes and subsidies)	€12,000	€27,000	€34,000	€26,000	€22,000
Driving range	700 km	1000 km	300 km	1100 km	1300 km
Fuel/electricity costs (per 100 km)	€9	€10	€7	€9	€14
YOUR CHOICE	☐	☐	☐	☐	☐

Fig. 1. Example of a choice task (for the small segment) proposed to the Italian respondents.

Table 7
RPL model estimates.

	ITALY	NORWAY
	Coeff. (t-stat)	Coeff. (t-stat)
Net purchase price$_{\text{All cars}}$ (in €1000)	−0.052 (−15.2)	−0.052 (−15.2)
SD of price	0.066 (17.1)	0.066 (17.1)
Driving range$_{\text{All but BEVs}}$ (in km)	0.0004 (3.9)	0.0002 (0.8)
SD of Driving range$_{\text{All but BEVs}}$	0.001 (10.1)	0.002 (10.9)
Driving range$_{\text{BEV}}$	0.001 (3.2)	0.003 (3.4)
SD of Driving range$_{\text{BEV}}$	0.002 (7.2)	0.005 (9.5)
Fuel\electricity cost$_{\text{All cars}}$	−0.134 (−11.1)	−0.209 (−12)
SD of Fuel\electricity cost$_{\text{All cars}}$	0.139 (11.7)	0.229 (13.6)
ASC$_{\text{Diesel}}$ (relative to petrol)	0.117 (2.8)	0.74 (8.6)
ASC$_{\text{HEV}}$ (relative to petrol)	0.592 (10.8)	0.55 (5.8)
ASC$_{\text{PHEV}}$ (relative to petrol)	−0.05 (−0.9)	0.593 (7.2)
ASC$_{\text{BEV}}$ (relative to petrol)	−1.354 (−3.2)	−1.586 (−1.4)
SD of ASC$_{\text{BEV}}$	0.939 (5)	2.169 (8.3)
Interaction between ASC$_{BEV}$ and socio-demographics		
ASC$_{\text{BEV}}$*Age	−0.151 (−2.5)	−0.166 (−1.4)
ASC$_{\text{BEV}}$*Female	0.22 (1.2)	−1.101 (−2.9)
ASC$_{\text{BEV}}$*Income	0.026 (0.3)	−0.138 (−0.7)
ASC$_{\text{BEV}}$*BEV density	0.39 (2.8)	0.035 (4)
ASC$_{\text{BEV}}$* BEV owner	2.353 (4.7)	3.971 (8)
Scale parameter (σ^{NOR}/σ^{IT})	1.579 (5.3)	1
Diagnostics		
LL(0)	−15,805	
LL(final)	−11,356	
Adj.Rho-square (0)	0.2792	
AIC	22,782	
BIC	23,034	
Estimated parameters	35	
Number of individuals	982	
Number of observations	9820	
Draws (Sobol)	1000	

Legend: Age: coded in age classes:1: 18–29 years old; 2: 30–39 years old; 3: 40–49 years old; 4: 50–59 years old; 5: more than 60 years old. Gender: coded as 1 for males and 2 for females. Income, coded in income classes. For the Italian sample, 1: less than €30,000; 2: from €30,000 to €70,000; 3: from €70,000 to €100,000; 4: more than €100,000. For the Norwegian sample, 1: Less than NOK 400,000; 2: Between NOK 400,001 and NOK 800,000; 3: Between 800 001 and NOK 1,200,000; 4: More than NOK 1,200,001. BEV density, expressed as number of BEVs per 1000 inhabitants in the region (5 macro regions for Italy and 11 counties for Norway). BEV owner coded as 1 if the respondent has a BEV, 0 otherwise.

5. Results

We tested different specifications, interacting the distributed parameters (ASC, price, range, and F\E costs) with several covariates (e.g., income, age, gender, garage ownership, place of residence and commuting distance). The model that produced the best goodness of fit is illustrated in Eq. (3).

As explained in Section 3, for identification purposes, in the joint model the price attribute is assumed to be generic across countries while the remaining model parameters are sample-specific. Table 7 reports the results. It can be seen that the parameters concerning the car attributes (net purchase price of the car, driving range and fuel\electricity costs) have the expected sign with low p-values. In the case of the distributed parameters, we tested the lognormal and normal distributions and opted for the latter using as criterion the goodness of fit, although it allows for controversial values. All the parameters show relevant levels of unexplained heterogeneity.

Comparing the estimated parameters between the two countries, it can be seen that the magnitude of the internal combustion engine vehicle (ICEV) driving range country-specific parameters are not very dissimilar between the two countries, implying a WTP for an additional driving range km equal to €7 (Rob. SE 2) in Italy and €3 (Rob. SE 4) in Norway[3]. With reference to the driving range of the BEVs, the implied WTP for an additional driving range km is equal to €20 (Rob. SE 7) in Italy and €52 (Rob. SE 19) in Norway. The fact the Norwegian drivers value more the driving range might be due to the higher daily travel distance in Norway than in Italy (Scorrano et al., 2019) and to the colder winter temperatures. Compared with previous estimates concerning Italy, our estimated WTPs are lower. In fact, Valeri & Danielis (2015) found a value of €50 per additional km of driving range, Valeri & Cherchi (2016) a value of €42, Giansoldati et al. (2018) a value ranging from 37 to 106 €/km, Danielis et al. (2020) a value of 29–66 €/km. There seems to be a decreasing trend, indicating a growing satisfaction with the driving range of the BEVs offered in the market. In the case of Norway, a comparison can be made with the results obtained by Noel et al. (2019) and by Fridstrøm & Østli (2022). Noel et al. (2019) conducted a survey between September 2016 and November 2017. In their model specification, they assumed a non-linear specification of range, providing different WTPs per each additional km range for five Nordic countries. For Norway, the values started at €300 per additional km for an initial driving range of 150 km, and declined at slightly less than €100 when the driving range is equal to 400 km. Fridstrøm & Østli (2022) used revealed preference data up to May 2019. They also estimated diminishing returns to range function and found that in a car with an initial range of 150 km, the revealed willingness-to-pay for an additional 100 km is €24,000. Conversely, when the initial range is 500 km, it drops to €5100. Considering that in 2021 the Tesla Model 3, the best-selling car in Norway, had a driving range slightly lower than 500 km, we can conclude that our estimates are in line with Fridstrøm & Østli (2022). Consequently, it appears that both in Norway and in Italy, the drivers' satisfaction with the BEV driving range is improving.

Respondents are also quite sensitive to fuel/electricity savings, with Norwegians having higher absolute values than Italians do. The explanation is not related to the fuel\energy prices, which are similar for petrol but lower in Norway for electricity as documented below (Table 11), but again with the higher driving distances and larger size of the car models in Norway than in Italy.

Finally, Table 7 reports the results concerning the ASCs of the different powertrains relative to petrol. The ASC is to be interpreted as the (dis)utility of all the variables not modelled in the systematic utility, thus capturing the relative utility of a powertrain *ceteris paribus* (i.e., all other modelled variables being equal). Respondents prefer diesel relative to petrol cars in both countries, more strongly so in Norway. HEVs are also strongly preferred to petrol cars in both countries, while PHEVs are preferred to petrol cars only in Norway.

[3] Please also note that we converted Norwegian price and cost variables from the Norwegian krone (NOK) to the Euro (one Euro corresponds to 10 NOK) to have parameter comparability across countries.

In the case of the BEVs, the interpretation of the results is more complex, because the ASC_{BEV} is assumed to be normally distributed and interacted with several socio-economic covariates that explain its heterogeneity. The non-interacted part is strongly negative and compatible with the data for Italy, while it is not for Norway since the confidence interval contains also positive or close to zero values. This is a major difference between the two countries. The interpretation is that, in addition to the impact of the socio-economic variables, Italian respondents value BEVs less than PVs, while that is not the case in Norway. Many factors might play a role. In fact, all factors not included in the model, such as the charging network, the regulatory set up but also latent variables (e.g., environmental concerns, excitement for new technologies, subjective norms, EV knowledge, etc.) are not accounted for by the model.

The interaction with the socio-economic variables indicates that older age is associated with lower preference for BEVs in Italy but not in Norway. Gender in Italy is not compatible with the data (see Amrhein et al., 2019), while in Norway men have a stronger preference for BEVs than women do. The finding about Norway is in line with previous studies (Coffman et al., 2017; Liao et al., 2017) and it is often motivated by the men's stronger interest towards new technology, but in contrast with the finding by Anfinsen et al. (2019) that men and women seem to be equally interested into BEVs. The lack of gender difference in Italy might reflect the skepticism of Italian men towards BEVs. Income plays no role in either country; this result, however, should be interpreted with caution given the hypothetical nature of the SP data. It might depend on the unreliable income self-reporting typical of many surveys (Bahamonde-Birke & Hanappi, 2016) or on the well-known hypothetical bias that affects stated choice data (Haghani et al., 2021a; Haghani et al., 2021b).

BEV density, expressed as number of BEVs per 1000 inhabitants in the macro-region, plays a role in both countries and it has a higher value in Italy. The higher the BEV density, the higher the probability of choosing a BEV. It indicates that space plays a role: some regions are more BEV prone than others and there is an imitation effect (I choose a BEV since many other peers in my region have chosen one). Such an imitation effect is stronger in Italy. Being a BEV owner also leads to assign a higher utility to BEVs. Both countries have a positive coefficient, but, in this case, the coefficient is higher in absolute term in Norway. It indicates that BEV owners are happy with their car experience and have a stronger tendency to prefer it to the other powertrains. Figenbaum et al. (2019) arrived at a similar conclusion via a direct survey. They documented that in 2018 94% of BEV owners would repurchase a BEV. Such finding is also confirmed by Hasan (2021) using a structural equation model.

The scale parameter, statistically different from 1, revealed relevant differences in unobserved heterogeneity in the two samples.

Overall, Norway's results signal a higher BEV propensity. In fact, there is no BEV aversion relative to PV (the ASC_{BEV} is not compatible with the data); BEVs are equally valued across age groups; men prefer BEVs while in the early stages they were usually critical towards BEV technical characteristics (Jensen et al., 2013). Moreover, BEV density plays a minor role (relative to Italy), and current BEV owners strongly confirm their choice. That is not the case in Italy, especially given the stronger preference *per se* for powertrains other than BEVs. Our explanation is that the Italians' hesitancy with BEVs is related to the still precarious implementation of the BEV ecosystem (i.e., charging network, parking regulation, manufacturers' support, etc.).

6. Scenario analysis

Based on the estimated model, we calculate how the predicted powertrains' market share would change relative to a baseline scenario under the following three scenarios:

Table 8
Cars' Net Purchase Price in Italy under baseline Scenario S.0 "Status quo" – 10 best-selling cars. All values are in euro.

	MSRP (incl. VAT)	RT (fixed)	RT (variable)	Subsidy*	NPP 2021	NPP2021/ MSRP
PV	19,265	151	259	1,295	18,380	95%
DV	29,641	151	345	1,393	28,744	97%
HEV	19,238	151	235	1,673	17,952	93%
PHEV	43,037	151	527	4,500	39,215	91%
BEV	30,574	151	403	6,500	24,628	81%

*Without scrapping.

S.1 – Italian car buyers face the same net purchase car prices and fuel \electricity costs as the Norwegian car drivers and vice versa.
S.2 – Italy adopts the Norwegian registration tax.
S.3 – Both Italy and Norway adopt a social cost internalizing registration tax.

6.1. Baseline scenario

The starting point of a scenario analysis is to establish the baseline scenario. To this aim, we opted to reconstruct the *status quo* scenario, that is the values of the three attributes (NPP, driving range, fuel\electricity cost) prevailing in 2021 in Italy and Norway. By applying these values to the estimated model, we expected the model to predict car market shares in line with those observed in the two countries. These will be used as baseline predictions against which to compare the estimates under the three formulated scenarios. Since it is well-known that a model estimated with SP data suffers from hypothetical bias, we do not expect to be able to exactly replicate the real-world market shares, but sufficiently close approximations.

The initial difficulty is, however, to estimate the values of the three attributes prevailing in 2021 for each powertrain. To this aim, we searched the available statistics concerning car sales, technical and environmental characteristics (tare weight, CO_2 and NOx emissions), their MSRPs, fuel\electricity consumption, and fuel\electricity costs. A summary of the collected information is reported in the Supplementary material (SM 4.0).

In the case of Italy, UNRAE provides a monthly report of 10 best-selling cars (brand and model type) for each drivetrain. Based on such information, we estimated the NPP for the year 2021 by each powertrain, as an average of the 10 best-selling cars, weighted on the relative sales number. The NPP is the sum of the MSRP (which in Italy is normally communicated including VAT), the fixed and variable part of the registration tax (RT) and the subsidy. As mentioned in Section 2.1, the subsidy differs when the car buyer decides to scrap the old car. In our calculations, we assumed that the subsidy without scrapping applies. It results that HEVs and PVs had the lowest NPP in Italy in 2021 (Table 8), well under 20 thousand euros per car.[4] This is largely the result of the fact the almost all of the 10 best-selling cars with these powertrains are of small or medium size (e.g., Fiat Panda, etc.). BEVs have an almost 5 thousand-euro higher NPP, notwithstanding being of similar small size and enjoying a 6.5-thousand-euro subsidy. DVs and especially PHEVs have much higher NPPs, mainly because they consist of larger size cars. Note also that compared with the MSRP, the NPP is always lower across all powertrains, in particular for BEVs that enjoy the highest subsidy. These estimates represent our best guess of the prices paid by car buyers in Italy in 2021 and will be used in the baseline scenario. In absolute terms, they suffer from three main drawbacks. Firstly, they are based only on the 10-best selling cars and not on the remaining ones. Secondly,

[4] As pointed out by an anonymous reviewer, the low MSRP of HEVs in Italy is due to the fact that they are mostly mild hybrid.

Table 9
Car's Net Purchase Price in Norway under baseline Scenario S.0 "Status quo". All values are in euro.

	MSRP	MSRP (incl. VAT)	Tare weight tax	CO_2 tax	NOx tax	Scrap tax	Tot RT	NPP	NPP/MSRP
PV	40,017	50,021	2083	3286	469	240	6078	56,100	140%
DV	52,185	65,273	5052	6710	625	240	12,627	77,900	149%
HEV	35,950	44,938	9182	1972	469	240	11,862	56,800	158%
PHEV	33,020	41,275	10,267	−5815	33	240	4725	46,000	139%
BEV	43,153					240	240	43,393	101%

Table 10
Selected values characterizing the different scenarios (NPP in €10^3, F\E costs in €/100 km).

	S.0 – ITA Italian NPP and F\E costs	S.0 – NOR Norwegian NPP and F\E costs	S.1 – ITA Norwegian NPP and F\E costs	S.1 – NOR Italian NPP and F\E costs
NPP_{PV}	19.3	56.1	56.1	19.3
NPP_{DV}	28.8	77.9	77.9	28.8
NPP_{HEV}	19.3	56.8	56.8	19.3
NPP_{BEV}	30.6	43.2	43.2	30.6
NPP_{PHEV}	43	46.0	46.0	43
$Range_{PV}$	700	1100	1100	700
$Range_{DV}$	800	1200	1200	800
$Range_{HEV}$	700	1200	1200	700
$Range_{BEV}$	230	480	480	230
$Range_{PHEV}$	900	1200	1200	900
$F\backslash EC_{PV}$	7.9	13	13	7.9
$F\backslash EC_{DV}$	7	11.2	11.2	7
$F\backslash EC_{HEV}$	7.1	10	10	7.1
$F\backslash EC_{BEV}$	5	2.5	2.5	5
$F\backslash EC_{PHEV}$	8.4	10	10	8.4

S.0 - Baseline scenario ITA: Italian NPP and F\E costs; S.0 - Baseline scenario NOR: Norwegian NPP and F\E costs.
S.1 - ITA: Norwegian NPP, Norwegian E\F costs; S.1 – NOR: Italian NPP, Italian E\F costs.
NPP: Net Purchase Price; F\EC: Fuel\Electricity costs.

we applied the without-scrapping-subsidy to all cars; this is certainly not the case for all car buyers and, more importantly, it assumes that there is enough public funding for all car buyers. We know that it was not the case because the allocated funds were limited and distributed on the first come, first served basis. Thirdly, it does not consider the common real-world practice of applying discounts to the MSRP by the car dealers. However, as long as these drawbacks apply similarly across powertrains, they should not have an important distortive impact on our estimates.

In the case of Norway, the Opplysningsrådet for veitrafikken (Road Traffic Information Council) publishes monthly data on vehicles registrations (https://ofv.no/registreringsstatistikk) and maintains a database of the more than 1800 cars imported in Norway, detailing their main technical characteristics and estimated prices that consumers have to pay, including the registration tax. They do not publish, however, detail data on the 10 best-selling cars by powertrain. They do publish monthly data on the 20 best-selling cars independent from the powertrain that happen to be mostly BEVs. Consequently, we built our baseline scenario based on the data for the 10 best-selling BEVs and on the most representative cars for the other powertrains, including the VW Golf (PV), VW T-ROC (DV), Toyota Rava (HEV) and Toyota Rava (PHEV). On the basis of the Norwegian car tax rules, BEVs have the lowest NPP, since all other powertrains are charged the tare weight, CO_2, NOx and scrap tax, while BEVs pay only the scrap tax (Table 9). Note the PHEVs receive a tax credit because they emit on average less than 87 g CO_2 per km.

Along the same lines, we estimated the *status quo* values for driving range and fuel\electricity costs. It should be considered that these values are our best guesses based on available statistics, car manufacturers and websites specialized in car reviews. All sources are described in detail in the SM 4.0. The results are the figures reported in the first two columns of Table 10.

It can be seen that the NPPs are quite different in the two countries. The differences between the cars' NPPs are the result of various policy, demand, and supply factors. The car policy factors have been already discussed in detail. The demand factors include the preference structure (small vs large cars, driving range, model type, and income). The supply factors relate to the car manufacturers marketing strategies which might differ among countries. These factors are interdependent (e.g., car fiscal policies influence the chosen car size and powertrain) and other factors such as urban density, road size, and parking availability might play a relevant role.

Concerning the driving range, since Italian cars are on average smaller than Norwegian ones, they have shorter driving ranges across all drivetrains. More specifically, Italian BEVs are estimated to have an average driving range in real traffic conditions of 230 km, while Norwegian BEVs of 480 km.

Relative to the fuel\electricity costs per 100 km, our estimates consider both the fuel\electricity efficiency of the cars (the 10 best-selling cars for each powertrain for Italy, and the best-selling cars for Norway) and the fuel\electricity prices prevailing in the two countries in 2021. In 2021, the average petrol price in Norway was equal to €1.65, slightly higher than in Italy (€1.62). The average diesel price in Norway was equal to €1.55, also slightly higher than in Italy (€1.49), but with a similar price differential between petrol and diesel. Electricity was, however, definitely cheaper in Norway: €0.13 per kWh versus €0.22 per kWh, on the basis of the gross price index of the household consuming yearly between 2500 and 5000 kWh. In this case, the price difference between the two countries is partly due to fiscal choices and partly to the differences in the electricity mix, mainly based on hydropower in Norway while relying more on natural gas in Italy. Combining the cars' fuel \electricity efficiency and fuel\electricity prices, we estimated a range of fuel\electricity costs per 100 km for each drivetrain and each country.

The values reported in the first two columns of Table 10 are then used to predict the number of times a given powertrain will be chosen, given the vehicle attribute parameters and the socio-economic characteristics of the sampled population using the sample enumeration technique. The resulting car shares are illustrated in Figs. 2 and 3.

It can be seen that they are close but not equal to the actual market shares. They tend to overestimate the share of the Norwegian fossil fuel-based cars (PVs, DVs and HEVs) and underestimate EVs (BEVs and PHEVs). In contrast, for Italy the model underestimates PVs and DVs, while it overestimates HEVs, PHEVs and BEVs. The mismatch is likely due to the fact that our predictions are based on SP data whose scale is most likely different from the scale that one would obtain by integrating revealed and stated preference data (Brownstone et al., 2000), an option that unfortunately is not available to us. Nonetheless, we believe that our scenario analysis retains a value since we perform a comparative static exercise, aimed at analyzing the impact of policies with respect to the baseline scenario.

6.2. Scenario 1 – Italian car buyers face the Norwegian net purchase car prices and fuel/electricity costs and vice versa.

As we have seen, Italians and Norwegians face a very different net purchase car price and fuel\electricity structure. How would Italian car

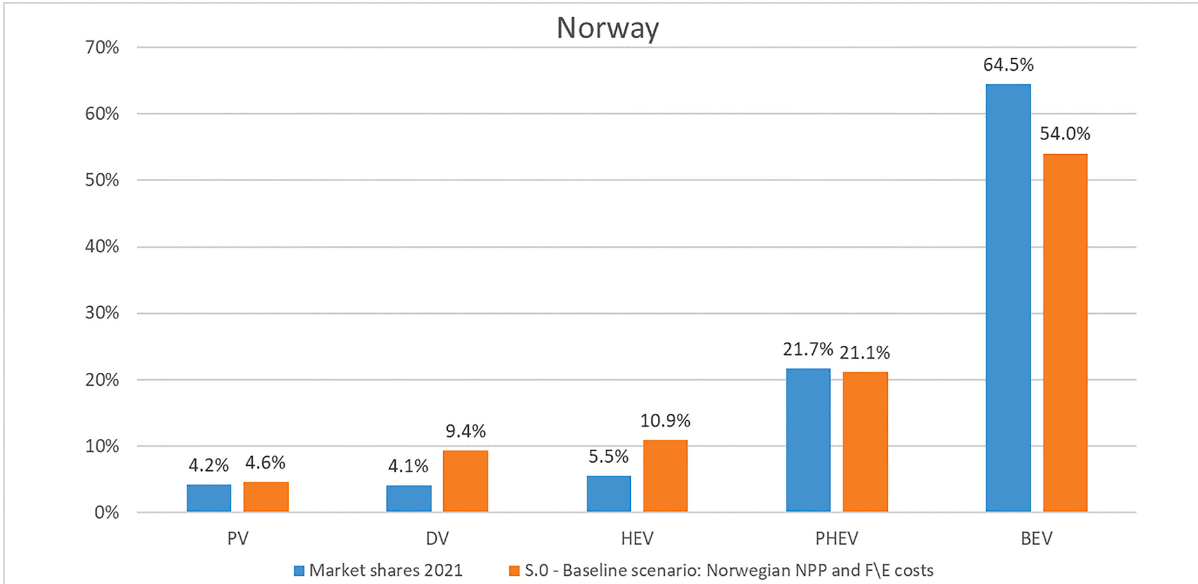

Fig. 2. Actual vs predicted share in Norway.

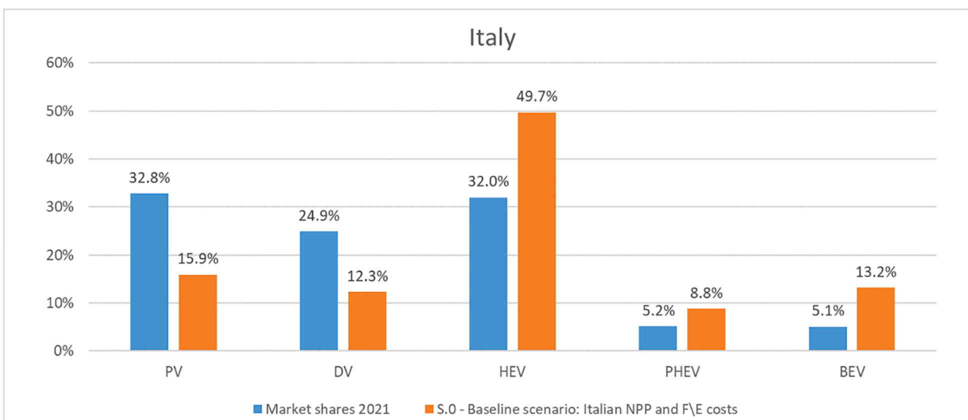

Fig. 3. Actual vs predicted share in Italy.

buyers react if they would face the Norwegian cost structure and how would Norwegian car buyers react if they would face the Italian one? This is estimated under Scenario 1. As described in the third and fourth column of Table 10, we assign the Norwegian attribute values to the Italians and vice versa. The results are illustrated in Figs. 4 and 5.

Preliminarily, it is worth noting that Scenario 1 is purely hypothetical since, as discussed above, the current NPPs are the results of structural differences between the two countries (country size, urban density, road size, etc.) and different car fiscal policy approaches. Moreover, the difference in the fuel\electricity costs is due to policy choices and natural resource endowments (water resources to produce electricity), and the difference in driving range is a consequence also of the above two cost differences. However, Italian car fiscal policies can be modified and electricity mix can be altered in favor to more sustainable and most likely cheaper energy sources such as solar and wind power.

As to be expected, under Scenario 1, with the Italian MSRPs, Norwegians would drastically increase the number of PVs, DVs and HEVs relative to the baseline scenario. PVs, DVs and HEVs would increase their market share by 8 (from 4.6 to 12.6), 9.4, and 15.3 percentage points, respectively. PHEVs would decrease their market share by 9.7 and BEVs by 23 percentage points. Although the BEVs share is still high, compared with the one predicted for Italy under the same conditions in the baseline scenario (13.2%), Norway would definitely switch to a mainly fossil-fuel based car country. With the Norwegian MSRPs, Italians would significantly increase the number of PHEVs and BEVs. Relative to the baseline scenario, their share would increase by 11.3 and 31 percentage points, respectively. PVs, DVs and HEVs would decrease their market share by 10.3, 2.9, and 29 percentage points, respectively. Note the huge loss in the HEV share, which is largely dominant with the current preference structure. Almost half of the Italian market share would be made up of BEVs, up to 64.2%, including PHEVs. However, Italy would still have a lower BEV and PHEV share than that predicted for Norway under the same values for the three attribute levels. This finding confirms that the Italian car preference structure is less EV inclined than the Norwegian one. Italians are still reluctant to embrace the electric car revolution. Factors other than simply the attribute values that we have identified restrain Italians from choosing EVs.

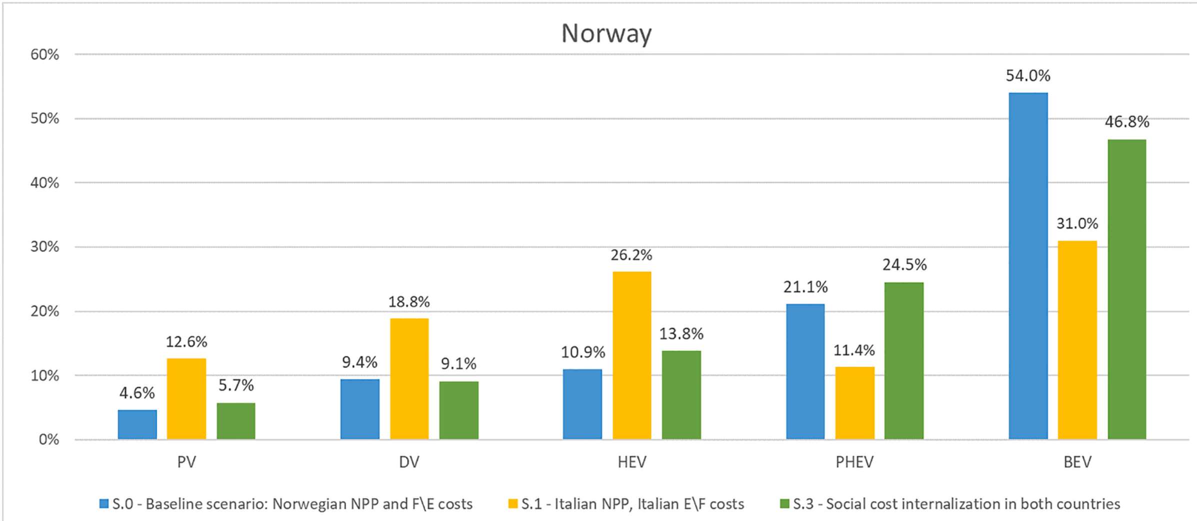

Fig. 4. Predicted shares under alternative scenarios in Norway.

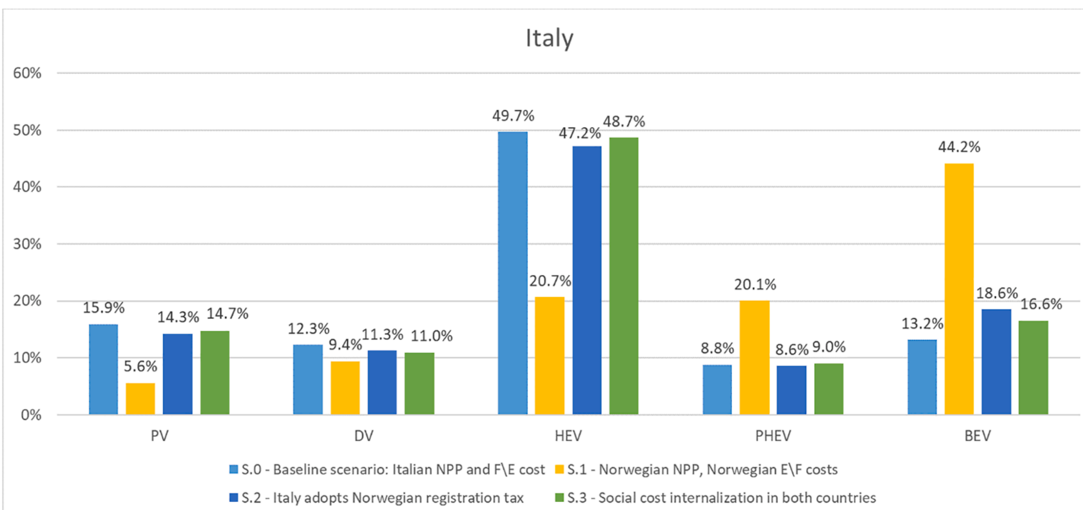

Fig. 5. Predicted shares under alternative scenarios in Italy.

Table 11
Cars' Net Purchase Price in Italy under Scenario S.2 "Italy adopts the Norwegian car registration tax" – 10 best-selling cars. All values are in euro.

	$MSRP^{ITA}$ (incl. VAT)	Tare weight tax	CO_2 tax	NOx tax	Scrap tax	RT^{NOR}	NPP	NPP/MSRP
	(1)	(2)	(3)	(4)	(5)	(6) = (2) + (3) + (4) + (5)	(7) = (1) + (6)	(8) = (7)/(1)
PV	19,265	1755	4386	469	240	6850	26,115	136%
DV	29,641	4279	4973	469	240	9961	39,602	134%
HEV	19,238	2017	3138	469	240	5863	25,102	130%
PHEV	43,037	7620	−4221	469	240	4108	47,145	110%
BEV	30,574	–	–	–	240	−6486	24,087	79%

6.3. Scenario 2 - Italy adopts the Norwegian car registration tax.

Scenario 2 assumes that Italy adopts the 2021 Norwegian registration tax based on (i) a progressive tare weight tax, (ii) a progressive CO_2 tax, (iii) a proportional NOx tax and a fixed scrap tax. Data are derived from the technical characteristics of each car. CO_2 emissions are charged when higher than 87 g/km. If lower, the registration tax is reduced. The registration tax is applied to PVs, DVs, HEVs, and PHEVs. PHEVs, however, receive an up to 15% discount on the tare weight, proportional to the distance driven in electric mode only. BEVs are exempt from all taxes but the scrap tax. Differently to the current Italian fiscal treatment, BEVs are also exempt from the 22% VAT. The detailed calculation for each of the 10 best-selling cars for each powertrain are reported in SM 3.0. The aggregate results are summarized in Table 11.

If Italy would adopt a car fiscal policy similar to the current Norwegian one, Italians would pay on the average of the 10 best-selling PVs 36% more, mostly because of the CO_2 tax (€4386). The tare weight tax would be on average equal to €1755 because the cars are of small size.

The NOx is equal to €469, conventionally calculated on 60 g/km, when, as in most cases, the NOx emissions are not reported in the websites, and the scrap tax is fixed to €240. The NPP for DVs would increase by a similar percentage, but by a total amount of about 10 thousand euros because of the tare weight tax and CO_2 emissions. The 10 best-selling HEVs would pay a limited registration tax, thanks to their lightweight and higher CO_2 efficiency. PHEVs, being very heavy due to the dual motor (internal combustion and electric) would pay a high tare weight tax, notwithstanding the fact their paying weight is reduced proportionally to the distance covered in electric mode only. Emitting less than 85 g/km of CO_2, they would be granted a registration tax reduction equal to €4221. As in Norway, we deducted from the Italian BEVs the 22% VAT and added the scrap tax. The impact of NPP is relevant.

Comparing the current MSRP including VAT, the NPP of PVs, DVs, HEVs increases by about 30%, that of PHEVs by 10%. On the contrary, BEVs' NPP decreases by 21%, thanks to the abolition of VAT. BEVs become the cheapest alternative, although by one or two thousand euros relative to HEVs and PVs. Consider also that, relative to Scenario 1, we have not assumed any increase in the driving range or decrease in the relative fuel\electricity costs. Hence, Scenario 2 identifies solely the impact of the fiscal system.

The impact is illustrated in Fig. 5. BEVs' market share would increase by 5.4 percentage points, while all other drivetrains would lose: PVs −1.6; DVs −1.0; HEVs −2.6; and PHEVs −0.2 percentage points. The percentage change is not dramatic because it is solely the impact of the NPP, the BEVs' driving range, relative fuel\electricity costs and all other issues (e.g. slow charging, insufficient charging infrastructure, overnight charging, etc.) would not change. The latter are incorporated into the ASC_{BEV} variable, that in Italy is strongly negative while that is not the case for Norway since the confidence interval contains also positive or close to zero values (see Section 4.3).

6.4. Scenario 3 – Non-preferential social cost internalization in both countries.

Scenario 3 assumes that both countries adopt a registration car tax policy that incorporates social costs and does not grant special privileges to BEVs. More specifically, we assume that Italy adopts the CO_2, NOx and tare weight taxes with rates equal to the Norwegian ones and, at the same time, eliminates the car subsidies and maintains the 22% VAT on all cars of all powertrains.

The average NPP for PVs, DVs, and HEVs would be the same as in Scenario 2, PHEVs' NPP would increase by 17% instead of 10% because of the higher tare weight tax. The BEVs' NPP would be reduced by 13% instead of 21% in the previous scenario since BEVs would be subject to VAT, tare weight tax (of a small amount given the average weight of the BEVs bought in Italy), the scrap tax but a negative CO_2, partly compensating the other taxes (Table 12).

The impact on the Italian market shares relative to the baseline is the following. BEVs would increase their market share 3.4 percentage points, PHEVs 0.2, while PVs, DVs, and HEVs would lose 1.2, 1.3, 1.0 percentage points, respectively.

In the case of Norway, we assume that the 25% VAT is extended to BEVs as well as the tare weight tax. Both assumptions increase the relative cost of BEVs, but such an increase is partially counterbalanced by the fact that the current Norwegian tax system grants a registration tax reduction to those cars that emit less than 87 g of CO_2 per km (tank-to-wheel). With regards to PHEVs, that are already subject to the tare weight tax, we eliminated the tare weight reductions granted in proportion of the distance travelled (up to 100 km) in electric-only mode (Table 13).

Again, relative to the baseline scenario, the impact is only on PHEVs that would cost more, and especially on BEVs that would become the second most expensive powertrain.

The interest for Scenario 3 lies in its more sustainable set up from the point of view of public finances. The subsidy system in place in Italy relies heavily on the scarce public funds. The public resources devoted to car subsidies are, at the same time, a burden on the State Budget and insufficient to satisfy the car drivers demand. In fact, the recent funds for the 60–135 g of CO_2 per km were exhausted just two days after the start of the program! For Norway, it is known that the one-off registration tax on passenger cars has been declining in line with the increasing market share of PHEVs and BEVs (Fridstrøm, 2019; Gunnar and Shiyu, 2021). The value of tax exemptions and reliefs benefitting BEVs in 2017 has been calculated at approximately NOK 7 billion, mostly due to the exemption from VAT (Fridstrøm, 2019). The advantageous BEV prices and their reduced variable costs may lead to an increase in car ownership and use at the expense of public transport. Another common criticism to BEVs incentives relates to tax progressivity as long as BEVs are bought by wealthier car users. More in general, there seems to be a need for rebalancing the corrective mechanisms by moving away from registration taxes and moving towards fuel taxes, which are more directly linked to car use and externality generation, as a way to influence both powertrain choice and car use.

The impact on the Norwegian market share relative to the baseline is the following. PVs would gain 1.2 percentage points, HEVs 2.9, PHEVs 3.4; DVs would lose 0.3, and BEVs would lose a considerable 7.2 percentage points.

7. Conclusions, policy implications, and study limitations

Our field research provided us with a picture of the car users' preference structure in the two countries. With reference to the car attributes, we found coefficient values not very dissimilar. The coefficients for ICEV and BEV driving range and the F\E costs are slightly higher in Norway due to longer trip distances and the colder weather conditions. The question whether Italians and Norwegians value cars differently thus received a partially negative answer: they value the main costs and performance components quite similarly. Instead, we found significant differences in the ASC_{BEV} parameter and in the impact of the socio-economic variables. In Italy, BEVs are, *ceteris paribus*, the least preferred powertrain. They are not equally valued across age groups: younger respondents are more prone to choose them, signaling an acceptance issue in the older age groups. BEV density plays a greater role in Italy than in Norway, indicating that in Italy BEVs space and proximity (imitation effects) are still needed for BEV choice.

The scenario analysis indicated that Norway is BEV-oriented and would comparatively preserve a high BEV share. If Norwegian drivers would face Italian car prices and fuel\electricity costs and driving ranges, they would choose BEVs less frequently but BEVs would still maintain a higher share than in Italy, under the same conditions. Other factors, such as the charging infrastructure, other BEV incentivizing policies, social factors, and past experience, probably act in favor of confirming the BEV choice. Even in the social cost internalization scenario, Norwegian car buyers would not reduce much their BEV choice. We estimate that PVs would gain 1.2 percentage points of market share, HEVs 2.9, PHEVs 3.4; DVs would lose 0.3 percentage points, and BEVs would lose 7.2 percentage points.

On the contrary, Italy is still non-BEV oriented: in the three scenarios, BEV share increases but to a lower extent. If Italian drivers would face the Norwegian car prices and fuel\electricity costs and driving ranges, they would choose BEVs more frequently, but without reaching the Norwegian levels. The non-monetary factors listed above most probably still prevent BEVs' acceptance in the Italian context. Under the more realistic scenario that Italy would adopt the Norwegian registration tax system, BEVs' market share would gain 5.4 percentage points, while all other drivetrains would lose: PVs −1.6; DVs −1.0; HEVs −2.6; and PHEVs −0.2. Under the social cost-internalizing scenario, BEVs' market share would not significantly improve; BEVs would increase by 3.4% and PHEVs by 0.2%, while PVs, DVs, and HEVs would lose 1.2%, 1.3%, 1.0%, respectively. In general, there seems to be a lock-in or path dependence effect that limits BEV penetration in Italy or prevents a

Table 12
Car's Net Purchase Price in Italy under Scenario S.3 "Social cost internalization" − 10 best-selling cars. All values are in euro.

	MSRP (incl. VAT)	Tare weight tax	CO_2 tax	NOx tax	Scrap tax	Tot RT	NPP	NPP/MSRP
PV	19,265	1755	4386	469	240	6850	26,115	136%
DV	29,641	4279	4973	469	240	9961	39,602	134%
HEV	19,238	2017	3138	469	240	5863	25,102	130%
PHEV	43,037	10,620	−4221	469	240	7108	50,145	117%
BEV	30,574	3612	−7967	–	240	−4115	26,459	87%

Table 13
Car's Net Purchase Price in Norway under Scenario S.3 "Social cost internalization" − 10 best-selling BEVs. All values are in euro.

	MSRP	MSRP (incl. VAT)	Tare weight tax	CO_2 tax	NOx tax	Scrap tax	Tot RT	NPP	NPP/MSRP
PV	40,017	50,021	2083	3286	469	240	6078	56,100	140%
DV	52,219	65,273	5052	6710	625	240	12,627	77,900	149%
HEV	35,950	44,938	9182	1972	469	240	11,862	56,800	158%
PHEV	33,020	41,275	13,267	−5815	33	240	4725	49,000	148%
BEV	43,153	53,941	17,522	−7967	–	240	9795	63,736	148%

decline of the BEV share in Norway.

What lessons can we learn from our study? As recalled above, Italy has a high car density: about 670 cars per a thousand inhabitants. A large number of cars is of small or medium size. In the last years, the major change has been the growth of HEVs, substituting both petrol and diesel cars. The second development has been the increasing but still modest growth of EVs, equally divided between PHEVs and BEVs. These developments are the result of several factors including the car buyers' preference structure and the fiscal car policies enacted. Nonetheless, because of the reduced average car size, the average CO_2 emissions of the Italian car fleet is relatively low. If improvements have to be made as a contribution to the decarbonisation of the transport sector in the spirit of the European directives, further changes need to take place including accelerating the transition from PVs and DVs to HEVs or, even better from the point of view of decarbonisation, to PHEVs and BEVs. Because of the important role of the registration tax in influencing car choice, recognized in the literature, adopting a more differentiated fiscal policy, including tax components accounting from the tare weight, CO_2 and NOx emissions, along the lines of the Norwegian tax system, could help reaching the goal of decarbonising the passenger car sector. Our scenario analysis suggests that the gains are substantial only if changes in the relative car prices are accompanied by increases in the BEVs driving ranges and if electricity costs become more competitive, the latter requiring investments in renewable and cheaper sources of energy production. However, as discussed, such a scenario is highly hypothetical and not realistic in the short-medium run.

A more plausible scenario concerns Italy adopting a Norwegian-type car fiscal system or social-cost internalization system. In such scenarios, improvements in the BEV share are to be expected but not to a dramatic extent at least in the short run. Two other conditions need to be met. The first one consists in making available in the market a compelling supply of competitive BEVs in the small-to-medium segments of the market. In fact, the current supply of small-sized and relatively "cheap" BEV models, in line with the needs of the Italian urban drivers and the Italian average income, has been scarce. Auto manufacturers have not adequately supplied the market, in general but especially in the small-size car segments.[5] With the right car supply and car fiscal policies, it can be expected that Italy would experience a sufficiently rapid BEV uptake. The switch from car policies that distribute public funds to almost all powertrains, reducing the cars' MSRP, towards a more differentiated car policy would also reduce Italy's car density per inhabitant, presently one of the highest in Europe. The second condition is the enhancement of BEVs' acceptance by improving the BEV ecosystem including the charging infrastructure, a more favorable regulatory system, a greater knowledge and experience with BEV deriving, for instance, from electric taxis, electric carsharing or public sector fleets. Although not explicitly tackled by our model, these factors can play an important role in spurring BEV penetration.

In Norway, BEV uptake is at world record level, yet it needs to be reconciled with the need to limit excessive public spending in indirectly subsidizing BEVs by exempting them from VAT and the tare weight tax. This is also in line with the aim to avoid increases in car density resulting in congestion, parking issues, and loss of public transport patronage. Our estimates indicate that car buyers' preference for BEVs is strong: BEV owners confirm their choice; BEVs are, *ceteris paribus*, equally valued as PVs, and the social-internalizing scenario would not lead to dramatic reductions of the BEV share. Yet, it would be advisable to dismantle BEV incentivizing policies in parallel with the reduction of the BEV production costs, which have been rapidly declining in terms of battery costs in the last decade but are not likely to decrease at the same pace in the coming years due to supply chain shortages.

The strong points of our methodology are that: (i) it is based on in-depth understanding of the individual's preference structure; (ii) it allows estimating the substitution among powertrains; (iii) it allows comparison among consumers' behavior in more than one country; (iv) it can be used for policy analysis. It should, however, be considered as complimentary to the methodologies described in the introductory section since it has some weak-points.

First of all, it needs to be recognized the ex-ante nature of our analysis. It shares all the advantages of ex-ante studies – i.e., the potential to evaluate hypothetical scenarios based on a theoretically sound and empirically tested behavioral model – but it needs to be complemented by ex-post evaluation studies. Second, since the model is estimated on the basis of stated preference data, it suffers from the hypothetical bias, which can be controlled and partially reduced by various techniques (Haghani et al., 2021a; Haghani et al., 2021b), but it remains inherent in the nature of the data. Third, it captures mainly the demand side of the market. Our methodology is not able to represent the system dynamics and the demand–supply interaction. These require other analytical tools and, interestingly, can be integrated with the results of a discrete choice model (Scorrano & Danielis, 2022). Consequently, our predictions do not have a time frame; it is likely that they capture short term car buyer reactions to the assumed policy scenario, but they do not encompass further adjustments regarding the interaction between supply, demand, and the development of the charging infrastructure.

[5] The IEA reports that the number of available electric car models by type in Europe in 2021 was the following: 9 BEVs in the small car segment, 11 BEVs and 30 PHEVs in the medium car segment, 7 BEVs and 2 PHEVs in the cross over segment, 21 BEVs and 14 PHEVs in the large car segment, and 34 BEVs and 48 PHEVs in the SUV segment. Source: https://www.iea.org/reports/global-ev-outlook-2022/trends-in-electric-light-duty-vehicles.

A final set of limitations concerns the model specification that we have considered: the RPL model. Although it accounts for preference heterogeneity, the RPL specification does not explicitly model psychological, sociological, or experience factors. Other model specifications, for instance, the integrated choice and latent variable model, would allow a more detailed description of the choice process but achieve a lower model fit and, consequently a lower predictive power, and would face difficult issues in using the model for policy analysis (Vij & Walker, 2016; Kroesen et al., 2017; Campbell & Sandorf, 2020). Consequently, for the purposes of our paper, that is predicting the impact of different policies on consumers' choice, we have opted for the simpler RPL specification.

CRediT authorship contribution statement

Mariangela Scorrano: Conceptualization, Data curation, Formal analysis, Software, Methodology, Writing – original draft, Writing – review & editing. **Terje Andreas Mathisen:** Conceptualization, Supervision, Validation, Writing – review & editing. **Romeo Danielis:** Conceptualization, Supervision, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Ozlem Simsekoglu:** Investigation, Writing – review & editing. **Giuseppe Marinelli:** Investigation, 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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Appendix A. Supplementary material

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