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Consumer preferences for business models in electric vehicle adoption

Fanchao Liao[a,*], Eric Molin[a], Harry Timmermans[b,c], Bert van Wee[a]

[a] Delft University of Technology, Faculty of Technology, Policy and Management, P.O. Box 5015, 2600, GA, Delft, the Netherlands
[b] Urban Planning Group Eindhoven University of Technology, P.O. Box 513, 5600, MB, Eindhoven, the Netherlands
[c] Department of Air Transportation Management, Nanjing University of Aeronautics and Astronautics, Jiangjun Avenue, Jiangning District, 211106, Nanjing, China

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ABSTRACT

Successful market penetration of electric vehicles may not only rely on the characteristics of the technology but also on the business models available on the market. This study aims to assess and quantify consumer preferences for business models in the context of Electric Vehicle (EV) adoption. In particular, we explore the impact of attitudes on preferences and choices regarding business models. We examine three business models in the present study: battery leasing, vehicle leasing and mobility guarantee. We design a stated choice experiment to disentangle the effect of business models from other factors and estimate a hybrid choice model. According to the results, the preferences for business models depend on the vehicle type: for battery electric vehicle (BEV), vehicle leasing is the most preferred option and battery leasing is the least preferred, while for conventional cars (CV) and plug-in hybrids (PHEV) the traditional business model of full purchase remains more popular. The attitudes of pro-convenience, pro-ownership and pro-EV leasing are all significantly associated with the choice of business models. As for mobility guarantee, we do not find any significant effect on utility. Finally, we discuss the implications for business strategy and government policy derived from our results.

1. Introduction

Road transport, which is mainly powered by fossil fuels, contributes to a wide range of sustainability problems, such as global warming, environmental pollution and oil dependency, etc. Substituting cars powered by internal combustion engines with electric vehicles (EV) at a large scale is expected to be a potential solution to the above problems. However, despite the effort of car manufacturers and strong promotion of many governments, EV sales remain rather low and its potential benefits are not fully realized. Apparently, the environmental benefits for society brought by EV are not highly valued by many consumers and are insufficient in itself to achieve a high market share (Siegel, 2009). The unattractiveness of EV for the mainstream market in comparison to conventional vehicles can be mainly attributed to the following shortcomings (Liao et al., 2017). First, the purchase price of EV is considerably higher in most countries due to the high battery costs. Second, the high amount of uncertainties surrounding EV: since EV applies relatively novel technologies, there are lots of uncertainties involved regarding issues such as battery life and speed of technological improvement, all of which have an impact and pose risks on the residue value of the vehicle. Third, most EVs have a shorter driving range relative to conventional vehicles and many consumers feel range anxiety; the limited number of charging stations and the rather long charging time (fastest charging time takes around 30 min) are cumbersome and inconvenient for many which further compounds the issue.

In order to overcome these barriers for market penetration, considerable attention and effort have been dedicated towards the research and development to improve the EV technology (Williander and Stålstad, 2013). However, novel technologies do not possess a fixed inherent value and their market value is contingent upon the manner in which their commercialization is carried out (Chesbrough, 2010). Commercialization takes place through *business models*, which describes how a company creates, delivers and captures value (Bohnsack et al., 2014). The most common business model for cars is full purchase – acquiring ownership of the car by paying the full purchase price. Some alternative business models for car adoption are vehicle leasing and battery leasing (only for battery electric vehicle). Pursuing the same technology in the market through different business models can yield different economic outcomes (Chesbrough, 2010). Hence, it is hard to find out how much of the low sales of EV can be attributed to the technology itself and how much to the traditional business models (Wells, 2013).

As we mentioned above, innovative sustainable technologies usually entail certain barriers for widespread market penetration, while current business models may be inadequate to address these barriers (Wells, 2004). Therefore, applying prevailing business models is unlikely to

* Corresponding author.
E-mail addresses: f.liao@tudelft.nl (F. Liao), e.j.e.molin@tudelft.nl (E. Molin), H.J.P.Timmermans@tue.nl (H. Timmermans), g.p.vanwee@tudelft.nl (B. van Wee).

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achieve market success (Beaume and Midler, 2009). Furthermore, innovative business models may be a prerequisite for sustainable technologies to become commercially viable and fulfill its potential in alleviating environmental problems (Budde Christensen et al., 2012).

If business models are found to be useful in increasing the market share of EVs, car manufacturers should pay more attention to providing innovative business models apart from focusing on improving EV technology; furthermore, the government should also dedicate some effort in stimulating business model innovation in addition to implementing financial purchase incentives and policies focusing on technical R&D (Birkin et al., 2007). Therefore, knowledge regarding consumer preferences in business models is of significant importance for the decision making of both car manufacturer marketing strategies and government EV promotion policies.

The preferences for business models are likely to be heterogeneous among the population. Apart from the common socio-economic variables, latent attitudes can also have important influence on preferences and choices. Attitudes depend on individuals' experience, values and lifestyles. Accounting for the impact of attitudes can both increase the explanatory power of the model and better characterize preference heterogeneity. Many previous studies on EV adoption have demonstrated the effects of latent attitudes such as pro-environmental (Daziano and Bolduc, 2013), general technology perception (Kim et al., 2014) and attitudes towards leasing (Glerum et al., 2014). Given the above research gaps, our study aims to contribute to the literature by investigating consumer choices regarding both car type and business model. In particular, we explore to what extent attitudes play a role in these choices. In order to do this, we collect stated preference data and apply a state-of-the-art hybrid choice model, which considers these effects simultaneously. In this paper, we first briefly explain the concept of business model and some common examples of EV business models; next, we elaborate upon the conceptual model and its specification in section 3, which is followed by a description of survey design and data collection in section 4. Section 5 presents the model results and the final section concludes the paper.

2. Background: business models

Based on existing theoretical frameworks, business models can be distinguished in terms of its three main components: (i) value proposition: the product/service offered by the company; (ii) value network: the way in which the product/service is produced/provided regarding the stakeholders involved; (iii) revenue model: the type of payment used by the company to charge customers (Kley et al., 2011; Bohnsack et al., 2014). In our paper, we focus on value proposition and revenue model since they are most directly related to customers. In the classical business model currently adopted by conventional cars, the value proposition is the full ownership of the vehicle and the revenue model is one-time payment of full purchase price. This widely accepted model, however, constitutes some obstacles when it is applied in the case of EVs, which poses questions on its suitability. First, the "sell-and-disengage" model lets consumers deal with all the risks: this is acceptable for conventional cars with which car drivers are familiar, but less so for EVs, which are still new to most. Many potential consumers are concerned about the multiple risks surrounding EV including battery life, maintenance accessibility, rate of technology development, and residue value. Second, although the total cost of EV ownership throughout its lifetime may be around the same or is even lower than those for gasoline cars (Bubeck et al., 2016), the high purchase price which has to be paid at once creates a financial barrier for many potential customers. By adjusting one or more of the three main components, new business models can add additional value regarding efficiency and novelty by cost reduction and product differentiation respectively (Zott and Amit, 2008).

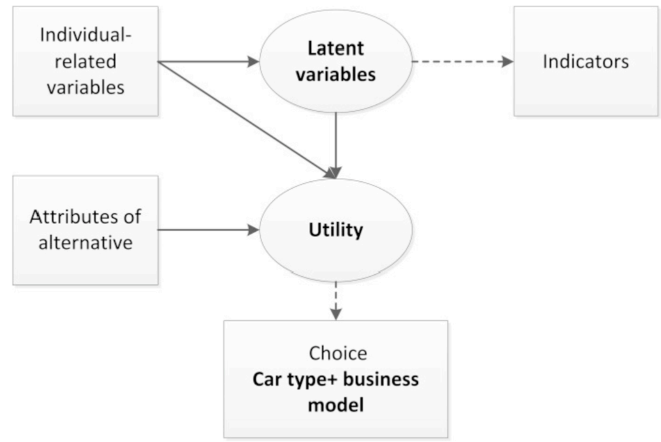

Fig. 1. Conceptual model.

In order to overcome key barriers, which are hindering EV market penetration and boost EV sales, many EV manufacturers have attempted adopting novel business models. They mainly made adjustments to the traditional business model in two ways: providing additional services by altering the value proposition or reducing initial purchase cost by changing revenue model (Kley et al., 2011). For a more exhaustive list of innovative business models for EV, see Bohnsack et al. (2014) and Kley et al. (2011).

In the academic literature, business models are mostly studied in the business and marketing field. There are also several studies regarding innovative business models for EV: Kley et al. (2011) utilized a holistic approach and identified the framework and building blocks for EV models which lays the foundation for future EV business model discussion. Wells (2013) provided a brief discussion of previous research regarding sustainable business models in the automotive industry and set an agenda for future research. Bohnsack et al. (2014) explored the impact of path dependencies of incumbents and startup firms in the EV industry on the evolution of their business models. However, most of these studies are either summaries of all potential business models or qualitative case studies focusing on a specific business model. Despite its wide application and high relevance with actual purchase choice in reality, insight in the impact of EV business models on EV adoption is still lacking.

To the best of our knowledge, the only studies on consumer preferences for EV which involved alternative business models are Glerum et al. (2014) and Valeri and Danielis (2015), both of which conducted a stated choice experiment including an EV alternative which has to be acquired via battery leasing. Glerum et al. also listed the leasing price of all alternatives and measured the attitude towards leasing. Despite the contribution of these studies, they share the main limitation that the impact of these business models is not disentangled from the effect of car brands and EV technologies. Therefore, the behavior change induced by providing new business models cannot be measured, making it difficult to draw conclusions regarding the potential of business models in increasing EV market penetration.

In this paper, we will focus on two of these new business models namely battery/vehicle *leasing* and mobility guarantee, since they do not require cooperation among various stakeholders (e.g. vehicle to grid) and drastic behavioral change of consumers (e.g. carsharing). Leasing is a business model in which consumers do not have the ownership of the car, nor do they pay the purchase price upfront. Instead, they have exclusive access to the car for a certain period of time (usually 3–4 years) by making a fixed monthly payment. In some countries (e.g. the Netherlands) this monthly rate also covers insurance cost, road tax and possible maintenance and repair costs. This model

Table 1
Selected attributes and their levels.

Attribute	Alternative	Level 1	Level 2	Level 3
Purchase price	Conventional car (PPC)	Defined by respondent		
	BEV(euro)	0.8*PPC +5000	PPC + 5000	1.2*PPC+5000
	PHEV(euro)	0.8*PPC +5000	PPC + 5000	1.2*PPC+5000
Energy cost	Conventional car	Defined by respondent		
	BEV(euro/100 km)	2	4	6
	PHEV(euro/100 km)	2	4	6
All-electric range (AER)	PHEV(km)	30	70	110
Driving range	Conventional car (km)	600		
	BEV(km)	150	300	450
	PHEV(km)	600 + AER		
Fast charging station density	BEV(km) (highway/urban)	50/0	75/5	100/10
Fast charging duration	BEV(minutes)	10	20	30
Policy incentive	BEV	None	Road tax exemption	Free public parking
Mobility guarantee	BEV (days per year)	0	7	14

Source: Liao et al., 2018.

has already been applied to both conventional and electric vehicles. In the US, the penetration of leasing in EV market was over 75% in 2015, in contrast to 28% in the overall car market.[1] However, it is not clear whether this performance can be generalized for other regions where private leasing is less popular or under different settings (such as the Dutch leasing model). In case of full battery vehicles, it is also possible to purchase the car body and only lease the battery. By changing the revenue model of the dominating business model, both types of leasing reduce the financial burden of initial purchase cost and make EVs more affordable. They also alter the value proposition by providing extra service (maintenance and warranty for battery/car), which creates additional value for consumers. Furthermore, it shifts part of the risks from consumers to the car manufacturer and significantly reduces the uncertainties regarding the residue value of the car. However, it also implies that consumers are no longer car "owners" and they have to pay more eventually if they wish to obtain ownership, which they may perceive as a negative point.

Mobility guarantee is a value adding service targeting a specific barrier namely range anxiety: it provides a substitute conventional car for EV adopters for a certain number of days per year to cover their occasional long trips. Limited range is widely found as one of the main shortcomings of EV technology and a barrier for its wide adoption (Zubaryeva et al., 2012). However, studies of travel behavior reveal that many drivers' current daily driving distance is well covered by the driving range of mainstream EVs, while the frequency of long trips which go beyond the EV range are rather low: if drivers can substitute a conventional vehicle for six days per year, electric vehicles with 160 km range can already meet the range needs of 32% drivers in the US (Pearre et al., 2011). Therefore, changing the value proposition by providing a conventional car for these rare occasions may help to overcome this barrier.

3. Modeling framework

In order to investigate the impact of business models on consumer preferences, we adopt a disaggregated approach and apply discrete choice modeling to study consumer decision-making. In basic choice models, the utility of alternatives is mostly specified as a linear combination of attributes of alternatives and a set of taste parameters. In order to find out consumer preferences for business models, we conceptualize each alternative as a combination of car type and its business model. Therefore, each choice set consists of 7 available alternatives, namely "buy CV", "buy BEV", "buy PHEV", "lease battery of BEV", "lease CV", "lease BEV" and "lease PHEV". The preferences for these alternatives are expected to be heterogeneous and depend on the socio-economic and socio-demographic variables of individuals. Furthermore, as empirical evidences indicate, psychological constructs such as attitude and perception also have a significant impact on the utility of alternatives and hence the final choice (McFadden, 1986). Therefore, we propose that attitudes towards business models affect consumer preferences as well. Attitudes can be measured by "indicators" which are responses to statements that describe an aspect of the attitude. Attitudes can also be partially explained by a series of individual-related variables, such as socio-demographics, etc. Fig. 1 illustrates the conceptual model.

In order to study the impact of all factors in the consumer preference model, we applied a hybrid choice model. Ben-Akiva et al. (2002) proposed a hybrid choice model to enable the inclusion of latent variables (usually psychological constructs). It consists of two sub-models: a latent variable model and a discrete choice model. The latent variable model is essentially a Multiple Indicators MultIple Causes (MIMIC) model (Zellner, 1970). It includes two components: a structural model describing the relationship between the latent variable and individual-related variables, and a measurement model, which specifies the relationship between the latent variable and the indicators.

The qth latent variable L^*_{nq} is assumed to be affected by a set of observable individual-related variables Z such as socio-economic characteristics. This is expressed as follows in the structural model:

$$L^*_{nq} = \gamma_{0q} + \sum_{z \in Z} \gamma_{qz} x_{nz} + \varepsilon_{nq},\ \varepsilon_{nq} \sim N\left(0, \sigma_{\varepsilon_q}\right) \tag{1}$$

where x_{nz} denotes individual-related variables of person n and ε_{nq} represents a disturbance term. γ_{0q}, γ_{qz} and σ_{ε_q} are parameters to be estimated.

The latent variable is identified by several indicators, which are usually responses to attitudinal statements on Likert scales. We assume the indicators are ordinal in measurement level and define the measurement model as follows:

$$z_{nd} = \lambda_{0d} + \lambda_d L^*_{nq} + \zeta_{nd},\ \zeta_d \sim N\left(0, \sigma_{\zeta_d}\right) \tag{2}$$

$$I^*_{nd} = \begin{cases} j_1 \ \ if\ z_{nd} < \tau_{q1} \\ j_2 \ \ if\ \tau_{q1} \le z_{nd} < \tau_{q2} \\ \vdots \\ j_i \ \ if\ \tau_{qi-1} \le z_{nd} < \tau_{qi} \\ \vdots \\ j_M \ \ if\ \tau_{qM-1} \le z_{nd} < \tau_{qM} \end{cases} \tag{3}$$

z_{nd} is a continuous latent construct of the dth indicator of person n I^*_{nd}, in which λ_{0d}, λ_d and ζ_{nd} are parameters to be estimated. The probability of individual n choosing j_i as the response for indicator I^*_{nd} equals the

[1] http://www.cnbc.com/2015/10/17/ric-cars.html.

[Choice task 3 / 6 Question 1 / 3]

Assume you can choose from the following three cars:

Attributes	Conventional vehicle	Battery electric vehicle (BEV)	Plug-in hybrid vehicle (PHEV)
Fuel cost	€13 per 100 km	**€2** per 100 km	**€4** per 100 km
Driving range with full fuel tank/battery	600km	**450km**	Electric range: **30km** Total range: **630km**
Fast charging station density		**On highway: one station every 100 km** **In cities:** Within **10 minutes** ride from the often visited locations	
Fast charging duration(till 80% of battery capacity)		**20 minutes**	
Governmental **incentive policies**	None	**Free public parking**	None
Number of days per year that you can make additional use of conventional car	n.a.	**14 days** per year	n.a.

We now ask you **three questions** regarding the choice between **these three cars**.

1. Suppose you only have the option to **purchase** the cars described above. The prices Of these three cars are listed below. Which of these three cars would you buy?

Conventional vehicle	Electric vehicle (BEV)	Plug-in hybrid vehicle (PHEV)
€24000	**€33800**	**€29000**
○	○	○

(a) 1st question

Your previous choice: [X]	[X]Conventional vehicle €24000	Battery electric vehicle €33800	Plug-in Hybrid vehicle €29000

2. Now for **battery electric vehicle, you can choose to buy the car body only and lease the battery pack for a fixed payment per month. The price of the car body and the monthly leasing payment of the battery pack are listed below. Which car will you choose?**

Purchase	Battery lease
I keep my previous choice	**Battery electric vehicle** **€28800** **+€80 per month** **for maximum milage of 15.000km per year, 5 cent per extra km**
○	○

(b) 2nd question

Your previous choice: [X]	Conventional vehicle €24000	[X] Battery electric vehicle €28800 +€80 per month for maximum mileage of 15.000km per year, 5 cent per extra km	Plug-in Hybrid vehicle (PHEV) €29000

3. Suppose you can also **lease** one of the three cars. The **monthly lease fee** for these three cars are listed below. **Would you like to lease one of these three cars** Or will you keep your previous choice?

	Private lease for maximum mileage of **15.000km** per year, **10 cent** per extra km		
I keep my previous choice	**Conventional vehicle** **€377 per month**	**Battery electric vehicle** **€533 per month**	**Plug-in Hybrid vehicle (PHEV)** **€473 per month**
○	○	○	○

(c) 3rd question

Fig. 2. Example of choice task (translated from Dutch).
Source: Liao et al., 2018.

Table 2
Sample characteristics.

Items		Value	Percentage
Socio-Demographics	Gender	Male	51.7
		Female	48.3
	Age	< =35 years	25.0
		36–50 years	24.0
		51–65 years	30.8
		> =66 years	19.2
	Number of household Members	1 person	16.8
		2 person	44.3
		3 person	16.7
		> =4 person	22.2
	Education level	No high education	56.6
		With high education*	43.4
	Monthly net personal income (euro)	< 625	6.8
		625–1250	10.6
		1251–1875	18.9
		1876–2500	30.3
		2501–3125	17.9
		> 3125	15.5
Information regarding car ownership and the expected car	Number of cars	0	1.0
		1	68.4
		2	27.6
		More than 2	3.0
	Purchase cost of expected car (1000 euro)	10-15	38.7
		16-20	24.2
		20-30	24.6
		> 30	12.5
	Fuel type of expected car	Gasoline	77.3
		Diesel	9.9
		LPG	1.6
		Hybrid	4.7
		BEV	2.6
		PHEV	2.4
		Others	1.6

Note: *: Those who received higher vocational or university education.
Source: Liao et al., 2018.

cumulative probability of value z_{nd} lies within the range of τ_{qi-1} and τ_q.

If we are using a Likert scale with 5 levels, we only have to define two positive parameters instead of four considering the symmetry of indicators (Bierlaire, 2016a):

$$\tau_{q1} = -\delta_{q1} - \delta_{q2}$$

$$\tau_{q2} = -\delta_{q1}$$

$$\tau_{q3} = \delta_{q1}$$

$$\tau_{q4} = \delta_{q1} + \delta_{q2}$$

In the discrete choice model part, the utility function of alternative j in choice situation t for individual n is:

$$U_{jnt} = \boldsymbol{\beta}_X \boldsymbol{X}_{jnt} + \boldsymbol{\beta}_L \boldsymbol{L}^*_{nq} + ASC_j + \varepsilon_n + \varepsilon_{jnt} \tag{5}$$

where $\boldsymbol{X}_{jnt}$ is a vector of vehicle attributes and $\boldsymbol{L}^*_{nq}$ is a vector of latent attitudes. $\boldsymbol{\beta}_X$ and $\boldsymbol{\beta}_L$ are vectors of coefficients to be estimated. ASC_j is the alternative specific constant. For each vehicle type, there are two or three corresponding alternatives and each of which denotes a combination with a business model. Between these two or three alternatives we expect unobserved communalities. In order to capture these communalities, we added normally distributed error component ε_{BEV} and ε_{PHEV} apart from the i.i.d. error term ε_{jnt}. Since each respondent answered 6 choice tasks, we used a panel data structure to capture the correlation by using individual-specific error terms for ε_n. Therefore, the unconditional probability of the sequence of choices for individual n can be written as follows (Ben-Akiva et al., 2002):

$$P_n = \int_{\varepsilon} \int_{L_n^*} \prod_t P_{jnt}(j|X,\, L^*_{n,}\varepsilon_n) \prod_d P(I^*_{nd}|L^*_n,\, \lambda_{0d},\, \lambda_{d,}\zeta_d) f(L^*_n|\gamma_z,\, x_{nz},\, \varepsilon_{nq}) dL^*_n\, d\varepsilon_n \tag{6}$$

in which the first term denotes the likelihood function of the choice model including latent variables, the second term represents the probability of indicators for a given respondent and the last term refers to the probability distribution of the latent variables.

We applied Pythonbiogeme (Bierlaire, 2016b) for model estimation, 1000 Halton draws were used when simulation was required.

4. Data collection

We collected data in June 2016 via an online survey which included a stated choice experiment. The survey was developed on a platform of the Urban Planning Group in Eindhoven University of Technology. The respondents were recruited from a Dutch panel monitored by a marketing research company. Since our target is potential car buyers, the following criteria have to be met for a respondent to be selected in our sample: 1) have a driver's license, 2) own a car or expect to buy a car in the following three years, 3) the car cannot be second-hand or a company leasing car since in those cases private leasing is not applicable. Our final dataset consists of complete answers from 1003 individuals. The same dataset has also been used by Liao et al. (2018) in another study on the impact of business models on electric vehicle adoption. In this section we explain the most important features of the survey and choice experiment in this article. For a more detailed description and design considerations please refer to Liao et al. (2018).In the choice experiment, the respondents assume that they are choosing their next car. They have to make a choice between three versions of the same car: a conventional car powered by gasoline or diesel, a full battery electric vehicle and a plug-in hybrid electric vehicle. The generic attributes which apply for every alternative include purchase price, energy cost and driving range. There are several additional attributes for BEV such as fast charging station density, fast charging duration, policy incentives and mobility guarantee. In contrast to most studies, the PHEV alternative in our experiment has an additional attribute: the all-electric range, which is the range it covers when it is solely powered by battery. The experiment is tailor-made for each respondent to make the choice tasks more realistic: the value of purchase price and fuel cost of the conventional car alternative are based on the respondents' own answers earlier in the questionnaire (see below). Table 1 lists the selected attributes and the values of different levels.

Apart from the choice on car types, we also collected the choice on business models. Therefore, the respondents had to answer three questions for each choice task: they were first asked to choose an alternative when they have to pay the full purchase price. Next, the respondents were asked whether they would update their choice if battery leasing is available for BEV. The extra information given regarding the battery leasing model includes the car body price and monthly battery leasing cost for BEV. Finally, the respondents could make another choice assuming that they can now also lease any of the three cars. The monthly leasing payments of the three vehicles were shown to the respondents. All monthly payments for leasing were calculated based on the purchase price and also customized for each respondent depending on their annual mileage. In order for respondents to have some basic knowledge of the business models, the respondents were also shown an information page at the beginning of the experiment, which introduced the business model of battery leasing and vehicle leasing which includes an explanation of what the monthly payment

Table 3
Results of multinomial logit model and mixed logit model.

Parameters		Multinomial logit model			Mixed logit model		
		Estimate	Standard error	p-value	Estimate	Standard error	p-value
Alternative specific constants							
BEV	Buy	−1.60	0.208	0.00	−3.91	0.347	0.00
	Battery lease	−2.22	0.213	0.00	−4.53	0.351	0.00
	Lease	−1.31	0.206	0.00	−3.62	0.347	0.00
	Standard deviation				4.32	0.212	0.00
PHEV	Buy	−1.32	0.104	0.00	−3.16	0.244	0.00
	Lease	−2.08	0.112	0.00	−3.91	0.247	0.00
	Standard deviation				3.98	0.198	0.00
CV	Lease	−0.964	0.0359	0.00	−0.964	0.0359	0.00
Attributes							
Relative purchase price	All	−0.127	0.00647	0.00	−0.239	0.0111	0.00
Energy cost	All	−0.111	0.0147	0.00	−0.174	0.0206	0.00
Driving range	BEV	0.0537	0.0301	0.07	0.105	0.0435	0.02
All-electric range	PHEV	0.265	0.106	0.01	0.671	0.159	0.00
Fast charging availability	BEV	−0.258	0.176	0.14	−0.228	0.252	0.37
Fast charging duration	BEV	0.0120	0.255	0.96	−0.00185	0.379	1.00
Road tax exemption	BEV	0.0843	0.0490	0.09	0.161	0.0697	0.02
Free public parking	BEV	0.0226	0.0519	0.66	−0.105	0.0761	0.17
Mobility guarantee	BEV	0.00928	0.0414	0.82	0.0129	0.06	0.83
Number of observations	6014						
Null-Likelihood	−11702.704						
Final likelihood		−9199.079			−7778.477		
Rho-squared		0.214			0.335		

Table 4
Parameter values of basic scenario.

Parameter	Value
CV purchase price	Expected car price
BEV purchase price	1.2* expected car price +5000 euro
PHEV purchase price	1.2* expected car price +5000 euro
BEV energy cost	4 euro/100 km
PHEV energy cost	6 euro/100 km
BEV driving range	200 km
PHEV all-electric range	50 km
BEV fast charging duration	30 min
BEV fast charging station density	50 km on highway
BEV policy incentive	None
BEV mobility guarantee	None

covers.

The choice tasks were generated using a D-efficient optimal design by Ngene (ChoiceMetrics, 2010). The priors for some taste parameters were taken from previous research findings (e.g. Hackbarth and Madlener, 2013; Hoen and Koetse, 2014). The final design consists of 12 choice tasks which were split into two blocks. Each respondent was randomly assigned to one of the blocks and had to complete 6 choice tasks. Fig. 2 gives an example of the choice task.[2]

Apart from the choice experiment, the online survey also included other information of the respondents including socio-demographics, current mobility pattern and the specifications of the next car they expect to purchase. Table 2 presented the descriptive statistics of the sample regarding their socio-demographics and basic characteristics of car ownership. Furthermore, we also measured respondents' attitudes towards leasing via ten attitudinal statements relevant for leasing. Each statement covers a possible aspect of motivation for preferring/disliking leasing, and is rated by a 5-point Likert scale ranging from "completely disagree" to "completely agree".

5. Results

This section first presents the result of a multinomial logit model which reveals consumer preferences for business models in case of different car types; next we elaborate the results of the hybrid choice model which show the effects of attitudes on consumer preferences. Both choice models are estimated based on only the final choice of respondents in each choice task, since in this study we only focus on the preference when all business models are available.

5.1. Consumer preference for business models

5.1.1. Model results

We would like to first find out which business model is the most preferred for each car type. Apart from the basic multinomial logit model, we also estimated an error components mixed logit model which adopted the error component structure explained in section 3. Table 3 shows the results of both models. In both the MNL and mixed logit model, alternatives with the same car type have utility functions of identical form; therefore, their alternative specific constants can be directly compared to identify consumer preferences for business models. From Table 3 we can see that for BEV vehicle lease is the favorite option and battery leasing is the least popular option. For a person who intends to purchase a 15,000-euro car, the willingness to pay for leasing a BEV is 1213 euro higher than buying a BEV according to the result of the error components model. For CV and PHEV it is the opposite: buying has a higher ASC in contrast to leasing (ASC for buying

[2] In the questionnaire interface, the table of attributes (other than purchase price/lease payment) is shown throughout the entire choice task (for all three questions). For question 2 and 3, this figure only shows the questions and do not repeat the table of other attributes which is the same as in question 1. A full interface display of question 2 and 3 can be found in the appendix.

Table 5
Simulation results of different policy scenarios.

Scenario	CV market share (%)	BEV market share (%)	PHEV market share (%)	EV market share (%)
0: Base scenario	75.7 (72.1–79.6)	14.0 (11.7–16.6)	10.3 (8.8–12.2)	24.3 (20.5–28.7)
1: Reduction of BEV purchase price	73.4 (70.0–77.1)	16.9 (14.1–19.9)	9.7 (8.5–11.3)	26.6 (22.5–31.2)
2: Reduction of BEV purchase price and leasing payment	70.7 (67.1–74.5)	20.3 (17.3–23.8)	9.0 (7.8–10.6)	29.3 (25.1–34.4)
3: Reduction of EV purchase price	70.5 (67.0–74.3)	15.7 (13.2–18.7)	13.8 (12.1–15.6)	29.5 (25.2–34.3)
4: Reduction of EV purchase price and leasing payment	67.2 (63.8–70.8)	18.7 (15.7–21.9)	14.1 (12.2–16.1)	32.8 (28.0–38.1)

Note: the 90% confidence interval of each market share is shown in the bracket below.

CV is set to 0) thus is the preferred option. This result shows that the value of leasing is different depending on the car type.

As for mobility guarantee, its impact on BEV utility is insignificant, which implies that this service does not play an important role when consumers making the choice of car type.

5.1.2. Application of the models: EV adoption under four policy scenarios

The results above imply that implementing financial incentives in case of leasing can also increase EV adoption. In order to illustrate the impact of the combination of financial incentive and leasing, we simulated the market share of the three car types under different policy scenarios. Table 4 lists the values of all vehicle attributes in the base scenario. The distribution of expected car price is based on our sample. The taste parameters are taken from the mixed logit model in Table 3. We calculated the choice probabilities for each alternative first on an individual level and then take the average. In order to calculate the confidence intervals, we take 100 draws for the taste parameters and for each draw of taste parameters 100 draws are taken for the random error components; therefore, in total we use 10,000 draws for each individual. Table 5 shows the market share of the three car types and their confidence intervals under the five different policy scenarios (including the base scenario without any policy incentives). The first policy scenario is a financial incentive which reduces the purchase price of BEV to only 5000 euro more than the expected car price only when consumers are buying: intuitively the market share of BEV increases to 16.9% compared to 14.0% in the base scenario; the share of PHEV slightly decreases but the share of EV in general (BEV and PHEV) climbs from 24.3% to 26.6%. When the financial incentive is also applied to leasing (new lease BEVs are only 5000 euro more expensive than the expected car price), the market share of BEV is further increased to 20.3%. In scenario 3 when this financial incentive is implemented on both BEV and PHEV but only when buying (not leasing), the market share for EV reaches 29.5% which is the highest compared to the previous two policies; however, most of the growth comes from PHEV while the share of BEV is even lower than when the incentive is applied to BEV buying only (15.7% vs 16.9%). From a policy perspective,

Table 6
Statements, scores and measurement model.

Statements	Average	Standard deviation	λ_d	λ_{0d}	σ_{ζ_d}	δ_1	δ_2
Factor 1 Pro-convenience							
Leasing is nice because I can switch cars regularly.	2.78	1.030	1	0	0	0.582 (0.0182)	0.896 (0.0287)
Leasing is nice because the risks of maintenance and damage are not for me.	3.33	0.928	0.645 (0.110)	0.502 (0.0467)	0.898 (0.0339)		
Leasing is nice because I know exactly how much I have to pay every month.	3.34	0.913	0.693 (0.112)	0.523 (0.0474)	0.874 (0.033)		
I find it important that a lot of hassle is gone when leasing a car.	3.12	0.931	0.794 (0.118)	0.313 (0.0487)	0.887 (0.0333)		
Factor 2 Pro-ownership							
I prefer to pay the total price at one time than paying each month.	3.73	0.977	1	0	0	0.497 (0.0178)	1.000 (0.0318)
I prefer to own a car than to lease one.	3.89	0.917	1.17 (0.233)	0.0457* (0.185)	0.942 (0.0388)		
Car lease is more suitable for company cars than for private cars.	3.55	0.967	0.906 (0.206)	−0.134* (0.164)	0.951 (0.0376)		
I do not want to lease a car because it is more expensive than buying a car.	3.49	0.950	0.635 (0.178)	0.0147* (0.142)	0.941 (0.0372)		
Factor 3 Pro EV leasing							
Leasing contract is more suitable for EV than for conventional cars.	2.9	0.849	1	0	0	0.817 (0.0244)	0.858 (0.035)
EV batteries are better to be leased than purchased.	3.14	0.758	0.825 (0.236)	0.286 (0.0502)	0.890 (0.0321)		

Note: 1) The standard errors of each estimated coefficient are in the parenthesis below.
2) All estimates are statistically significant apart from the ones marked with asterisk.

Table 7
Structural model of latent variables.

Latent variable	Parameter	Estimate	Std. error	p-value
Pro-convenience	Intercept	**−0.387**	0.0741	0.00
	Male	0.0446	0.0417	0.28
	Younger than 40	**0.128**	0.0518	0.01
	Number of household members	0.00293	0.00623	0.64
	Presence of young children (4–12 years)	**0.233**	0.0639	0.00
	Presence of teenage children (13–17 years)	−0.00672	0.0669	0.92
	High income (> 3125 euro)	**−0.199**	0.0629	0.00
	High education (University)	0.00408	0.0445	0.93
	Employed	**0.141**	0.0693	0.04
	Retired	*−0.144*	0.0799	0.07
	Student	**0.278**	0.129	0.03
	Have more than one car	**−0.128**	0.0468	0.01
	Standard deviation σ_{ε_1}	**0.258**	0.0291	0.00
Pro-ownership	Intercept	**0.848**	0.0679	0.00
	Male	−0.0414	0.0361	0.25
	Younger than 40	0.0684	0.0446	0.12
	Number of household members	−0.000961	0.00537	0.86
	Presence of young children (4–12 years)	**−0.186**	0.0559	0.00
	Presence of teenage children (13–17 years)	0.0274	0.0577	0.63
	High income (> 3125 euro)	0.0804	0.0548	0.14
	High education (University)	**0.0834**	0.0395	0.03
	Employed	**−0.135**	0.0612	0.03
	Retired	0.0996	0.0711	0.16
	Student	**−0.289**	0.116	0.01
	Have more than one car	0.0218	0.0395	0.58
	Standard deviation σ_{ε_2}	**−0.167**	0.0292	0.00
Pro EV leasing	Intercept	**−0.287**	0.0915	0.00
	Male	0.0605	0.0540	0.26
	Younger than 40	**0.230**	0.0693	0.00
	Number of household members	−0.00444	0.00802	0.58
	Presence of young children (4–12 years)	0.0903	0.0788	0.25
	Presence of teenage children (13–17 years)	0.0809	0.0863	0.35
	High income (> 3125 euro)	0.0193	0.0758	0.80
	High education (University)	−0.000758	0.0560	0.99
	Employed	0.104	0.0884	0.24
	Retired	0.0353	0.101	0.73
	Student	0.0574	0.171	0.74
	Have more than one car	**−0.153**	0.0654	0.02
	Standard deviation σ_{ε_3}	**0.123**	0.0278	0.00

implementing the incentive on BEV leasing instead of PHEV buying could be an attractive option since BEVs are zero emission vehicles and can have larger environmental benefits compared to PHEVs. Lastly, if the incentive is applied to both BEV and PHEV under all business models, the market shares of both types of EV are higher than in scenario 3, but the share of BEV is still lower than in scenario 2. Note that the costs of the policies also need to be considered in real world policy

Table 8
Discrete choice model part of the hybrid choice model.

Parameters		Estimate	Standard error	p-value
Alternative specific constants and standard deviation				
BEV	Buy	−1.91	0.318	0.00
	Lease battery	2.25	1.63	0.17
	Lease	10.9	3.15	0.00
	Standard deviation	0.781	0.102	0.00
PHEV	Buy	−1.53	0.187	0.00
	Lease	9.34	2.92	0.00
	Standard deviation	0.584	0.0865	0.00
CV	Lease	9.87	2.20	0.00
Attitudes				
Pro convenience	Lease CV	9.06	1.22	0.00
	Lease BEV	8.76	2.64	0.00
	Lease PHEV	11.8	1.79	0.00
Pro ownership	Battery lease BEV	−6.79	1.79	0.00
	Lease CV	−12.9	2.43	0.00
	Lease BEV	−16.5	3.71	0.00
	Lease PHEV	−16.1	3.47	0.00
Pro EV leasing	Battery lease BEV	6.02	1.82	0.00
	Lease BEV	9.24	4.59	0.04
	Lease PHEV	0.863	1.49	0.56
Socio-economic variables				
Male	Buy BEV	−0.273	0.124	0.03
	Buy PHEV	−0.0628	0.0989	0.53
	Battery lease BEV	0.296	0.438	0.50
	Lease CV	0.0554	0.602	0.93
	Lease BEV	−0.133	0.881	0.88
	Lease PHEV	0.0283	0.774	0.97
Younger than 40	Buy BEV	0.3	0.148	0.04
	Buy PHEV	0.0415	0.124	0.74
	Battery lease BEV	−0.352	0.656	0.59
	Lease CV	0.594	0.737	0.42
	Lease BEV	−0.558	1.35	0.68
	Lease PHEV	−0.0632	1.04	0.95
Number of household members	Buy BEV	−0.0509	0.0599	0.40
	Buy PHEV	−0.0228	0.0267	0.39
	Battery lease BEV	0.00926	0.0689	0.89
	Lease CV	−0.0291	0.0904	0.75
	Lease BEV	0.0166	0.132	0.90
	Lease PHEV	−0.0831	0.136	0.54
Presence of young children	Buy BEV	0.646	0.20	0.00
	Buy PHEV	0.369	0.16	0.02
	Battery lease BEV	−0.368	0.657	0.58
	Lease CV	−1.68	0.911	0.07
	Lease BEV	−2.19	1.30	0.09
	Lease PHEV	−2.03	1.18	0.08

(*continued on next page*)

Table 8 (*continued*)

Parameters		Estimate	Standard error	p-value
Presence of teenage children	Buy BEV	0.0456	0.215	0.83
	Buy PHEV	−0.253	0.173	0.14
	Battery lease BEV	0.284	0.701	0.69
	Lease CV	0.568	0.965	0.56
	Lease BEV	0.514	1.43	0.72
	Lease PHEV	1.32	1.24	0.29
High income	Buy BEV	−0.735	0.194	0.00
	Buy PHEV	−0.356	0.142	0.01
	Battery lease BEV	−0.471	0.636	0.46
	Lease CV	2.00	0.905	0.03
	Lease BEV	1.65	1.37	0.23
	Lease PHEV	2.58	1.17	0.03
High education	Buy BEV	0.715	0.128	0.00
	Buy PHEV	0.606	0.103	0.00
	Battery lease BEV	0.654	0.476	0.17
	Lease CV	1.33	0.66	0.04
	Lease BEV	2.40	0.957	0.01
	Lease PHEV	2.23	0.86	0.01
Employed	Buy BEV	0.211	0.191	0.27
	Buy PHEV	0.0269	0.152	0.86
	Battery lease BEV	0.196	0.827	0.81
	Lease CV	−2.26	1.03	0.03
	Lease BEV	−3.37	1.49	0.02
	Lease PHEV	−2.46	1.34	0.07
Retired	Buy BEV	−0.487	0.236	0.04
	Buy PHEV	−0.201	0.175	0.25
	Battery lease BEV	1.82	0.909	0.05
	Lease CV	2.27	1.19	0.06
	Lease BEV	2.92	1.76	0.10
	Lease PHEV	3.93	1.56	0.01
Student	Buy BEV	1.00	0.345	0.00
	Buy PHEV	0.434	0.304	0.15
	Battery lease BEV	0.393	1.43	0.78
	Lease CV	−4.51	1.92	0.02
	Lease BEV	−5.35	2.79	0.06
	Lease PHEV	−3.9	2.48	0.12
Have more than one car	Buy BEV	0.125	0.136	0.36
	Buy PHEV	0.453	0.106	0.00
	Battery lease BEV	1.51	0.552	0.01
	Lease CV	1.62	0.679	0.02
	Lease BEV	3.01	1.09	0.01
	Lease PHEV	2.38	0.892	0.01
Attributes				
Relative purchase price	All	−0.138	0.00722	0.00
Energy cost	All	−0.113	0.0160	0.00
Driving range	BEV	0.0664	0.0335	0.05
All-electric range	PHEV	0.21	0.112	0.06
Fast charging availability	BEV	−0.245	0.198	0.22
Fast charging duration	BEV	−0.0746	0.286	0.79
Road tax exemption	BEV	0.103	0.0554	0.06
Free public parking	BEV	−0.0279	0.0581	0.63
Mobility guarantee	BEV	0.00759	0.047	0.87
Number of observations		6014		
Choice model Log-likelihood		−8101		
Rho-squared		0.308		
Full model null Log-likelihood		−38307		

Table 8 (*continued*)

Parameters	Estimate	Standard error	p-value
Final Log-likelihood	−20845		
Rho-squared	0.456		

decisions.

5.2. Preference heterogeneity: the effect of socio-economic variables and attitudes

5.2.1. Attitude towards leasing

The online survey included ten attitudinal statements related to leasing, each statement describing a possible motivation or reason for preferring/disliking leasing. A 5-point Likert scale was used for rating, namely "completely disagree", "disagree'," "neutral', "agree", and "completely agree". Table 6 lists the statements, the mean and standard deviation of their scores and the parameter estimates in the measurement model.

First, we conducted an exploratory factor analysis to extract factors and derive three factors as shown in Table 6. Scoring high on the factor of pro-convenience implies that someone finds leasing to be beneficial because it saves trouble and reduces risk. A high score on the pro-ownership factor means car ownership is preferred to leasing in multiple aspects of consideration. The last factor Pro EV leasing stands for the view that leasing is more suitable for EV than for conventional vehicles. From the scores we can see that in general many people can recognize and appreciate the convenience brought by private leasing, but the vast majority are more or less emotionally attached to owning a vehicle and do not like the idea of leasing. As for the suitability of leasing for EV, the close to neutral average score and the relatively small standard deviation suggests that many people may not have sufficient knowledge to hold an opinion.

Table 6 also presents the measurement relationships between indicators and latent attitudes. The parameters of the first indicator are fixed so the other parameters in the measurement model can be identified. Therefore, the estimated effects of other indicators are relative. All indicators are positively and significantly related to their corresponding latent attitudes (see λ_d), which shows that people with a higher score of a latent attitude are more likely to agree with the corresponding statements.

Table 7 shows the estimation results for the structural model of the three latent variables. Several socio-demographic and socio-economic variables are significantly associated with these latent attitudes. The results reveal that people who are younger than 40, employed or student or have young children appreciate the convenience of leasing more. However, those who are retired, have higher income or own more than one car tend to recognize the convenience of car lease to a lesser extent in contrast to others. As for the attitude towards car ownership, males, parents with young kids, workers and students are less attached to car ownership. On the other hand, people with high degrees appreciate car ownership more than those who do not. Regarding the suitability of leasing for EV, people younger than 40 are more likely to agree that leasing is more suitable for EV than conventional cars, while those with more than one car agree to a lesser extent. Of all tested individual-specific variables, gender, number of household members and the presence of teenage children have no significant effect on any of the latent attitude variables.

5.2.2. Choice model

Table 8 presents the estimation results of the discrete choice model part of the hybrid choice model. Almost all effects of latent attitudes on business model preferences are statistically significant. The results show that pro-convenience is found to be positively associated with the leasing option of all three car types. The effect is especially strong for BEV vehicle leasing, which shows that the additional convenience brought by leasing is an important consideration especially for BEV. The effect of pro-ownership is negative for all four alternatives with alternative business models as expected. The size of the effect differs widely for different business models and car types. The effect is the smallest for battery leasing, which is intuitive since the individual who chooses battery leasing still owns the car body. The magnitude of this effect is especially large for BEV and PHEV: this indicates that for a person valuing ownership relatively high, the aversion towards leasing an EV is stronger than towards a CV. As for the attitude of pro EV leasing, it has a significant positive impact on both battery leasing and vehicle leasing for BEV, which is an intuitive result; and the effect is stronger for battery leasing than vehicle leasing, which implies that the difference between the utility of battery leasing and vehicle leasing is smaller for a person who is more pro- EV leasing than average when all else being equal. On the other hand, pro-EV leasing does not seem to have an impact on PHEV lease, which suggests that PHEV may have a vastly different image and concept in consumers' mind in contrast to BEV.

We included interaction items of socio-economic variables with ASCs to investigate their effect on the general preference for each alternative. Since we also incorporated latent attitudes in the utility function of alternatives with leasing, these socio-economic variables can affect the utility both directly on ASC and indirectly via latent attitudes. We can deduce the combined effects from the results of both the structural latent variable model and the choice model. For example, people who have young children prefer to buy BEV and PHEV (0.646 and 0.369). As for the effect of young children's presence on the utility of leasing BEV, it can be calculated as -2.19 (direct) $+8.76*0.233$ (indirect via pro-convenience) + $(-16.5)*(-0.186)$ (indirect via pro-ownership) = 2.92; therefore, it has a positive net impact. In fact, people who have young children have a higher preference for all four alternatives associated with (battery or vehicle) leasing. Many other socio-economic variables also have a significant net impact on the utility of the alternatives:

- Younger people (less than 40 years old) also have higher preference for all four leasing alternatives; the variable "young" also has a positive impact on buying BEV alternative but not PHEV.
- Higher income earners have lower preference for buying BEV and PHEV and are also less interested in battery leasing, but they prefer leasing CV and PHEV.
- Those who are highly educated prefer buying BEV and PHEV and are also more interested in vehicle leasing in terms of all three car types than those with less education, while they have less preferences for battery leasing.
- As for the influence of occupation, students have the highest preference for buying BEV and PHEV while retired people's preference are the lowest; however, concerning the preference for leasing, students still have the highest interest while those employed are the least interested. This is likely due to the fact that many employees lease car via a company deal but we excluded these people from our sample.
- Having more than one car in the household also contributes positively to the utility of buying both types of EVs and all four leasing alternatives.
- Gender, number of household members and the presence of teenage children do not have any significant direct nor indirect effect on utilities.

As for the estimated parameters of other vehicle attributes, most are significant and have the expected sign. Purchase price and fuel cost both have a negative effect on the probability of a car being chosen. Driving range of BEV has a positive impact on its utility. A point worth noticing is that consumers strongly prefer PHEVs with longer electric range. As for the fast charging station density and charging duration, neither of them is significant. This can be due to the following reasons: 1) consumers are genuinely indifferent for these two attributes as long as their value fall in between the range given in the choice experiment; 2) only a small group of people consider BEVs and have a clear preference for these two attributes: this effect may become insignificant on average in the entire sample. Regarding the two incentive policies, road tax exemption seems to have a positive impact on the attractiveness of BEV while the effect of free public parking is insignificant.

6. Conclusions and discussion

In order to facilitate a higher market penetration of EVs, most efforts have been focused on technological improvement while the potential of business model in promoting EV sales is often ignored in both the academic literature and public policy making. The present study contributes to the literature by examining consumer preferences for different business models regarding the decision of EV adoption; in particular, we investigated how these preferences can be affected by their latent attitudes. This knowledge can serve as valuable input for making EV promotion policies and strategies. We collected stated preference data and responses to attitudinal statements related to leasing from potential consumers. In order to simultaneously assess the impact of vehicle attributes and consumers' latent attitudes, we estimated a hybrid choice model to analyze the data.

Our results show that for BEV, vehicle leasing is the most popular option while battery leasing is less preferred than full price purchase. However, the preference for business models is exactly the opposite for CV and PHEV: the traditional full price purchase is preferred to vehicle leasing. This provides several interesting insights: first, it shows that providing vehicle leasing indeed has added value for BEV, while battery leasing is the least favorite business model on average, which implies that it may only be appealing for a rather small group; second, the impact of vehicle leasing varies for different car types: in contrast to BEV, people would still rather stick to one-time purchase instead of leasing with a monthly payment when adopting CV and PHEV. Furthermore, providing mobility guarantee for up to 2 weeks per year does not significantly increase the attractiveness of BEV, which indicates that it does not play an important role in decision-making when being juxtaposed with the other attributes in the choice experiment.

As for the impact of latent variables on business model preferences, almost all effects tested are statistically significant. Higher appreciation for the convenience of leasing leads to higher probability of choosing vehicle leasing for all three car types, which implies that apart from the reduced financial burden of paying full price in one go, the increased convenience is also taken into account when choosing vehicle leasing. On the other hand, people who appreciate car ownership are less likely to choose leasing. Moreover, those who believe that EVs are more suitable for leasing than conventional vehicles are more likely to adopt BEV via battery and vehicle leasing, while it does not have a significant impact on the probability of leasing PHEV.

Some implications for policy making and marketing strategies can be derived from our results. First, for both types of EVs, the implementation of financial incentive in the leasing business model can further increase their market shares than when they are only applied in buying. Given this insight, governments can extend their existing or planned incentives for EV purchase and make them also applicable for leasing; they can also offer some extra incentives to reduce the cost of implementing this business model. A point worth noticing is that subsidizing PHEV can reduce the market share of BEV; therefore governments shall choose the combination of applicable car types and business models depending on their goals (e.g. whether to promote all EVs or only those with zero-emission such as BEV). Second, in the case of BEV, vehicle leasing is significantly preferred to buying which implies that vehicle leasing has added value for BEV adopters. In order to ensure that potential BEV adopters are aware of and can benefit from it, car manufacturers can work on familiarizing potential BEV adopters with leasing and providing easy access to leasing which reduce the transaction cost of this business model, including offering customized advice regarding the selection of lease company/plan and simplifying the procedure of leasing, etc. However, our model also shows that the relative consumer preference for leasing and buying are reversed for BEV and PHEV, and the impact of pro-EV leasing attitude also differs for BEV and PHEV vehicle leasing. These results seem to suggest that consumers regard these two types of EV differently and these two should not be mixed up when discussing and making promotion policies and strategies regarding EV and leasing. Third, as we elaborated above, consumer preferences for business models are found to be highly heterogeneous and significantly influenced by people's individual-specific variables; therefore, it gives guidance for identifying those people who are more likely to choose leasing. Furthermore, informational campaigns on leasing and policies/marketing strategies which facilitate leasing shall ideally be tailor-made for target population according to their characteristics. For example, people's attitudes have a significant impact on their preferences for leasing, which sheds some light into the possible motivations for people's interest (or lack of interest) for leasing. Having this knowledge, information campaigns/promotions for leasing shall take all these motivations (higher convenience/less financial burden) into consideration. The relation between attitudes and socio-economic variables with preferences also provide insights helpful for identifying potential customers' which have strong interest for leasing and EVs, which can eventually fulfill the potential of business models in facilitating more EV adoption.

This research also has some limitations: first, it only included a fixed price level (a fixed percentage of the purchase price) for each battery leasing and vehicle leasing option, which made it impossible to investigate the effect of pricing scheme on the popularity of business models. Also, the highest level of mobility guarantee tested is only 14 days, which may still be insufficient for some people. Second, the context of the choice experiment is to choose from three different powertrain versions of the same car model and leasing is available for all three versions, which is an over-simplified version of the real world. It may be also interesting to explore how the consideration of business model trade-off with car types, brands and models when business models are not provided for all cars.

We also recommend several directions for future research regarding the impact of business models on consumer preferences for electric vehicles and other sustainable technologies: first, latent class models can be applied to systematically characterize and explain the origin of the heterogeneity underlying consumer preferences for business models. Second, the current model in our study can be further extended to incorporate more potential influential factors and relationships, such as the interaction between latent attitudes and vehicle attributes, etc. Some attribute coefficients can also be made specific for different business models, since attributes such as purchase price, fuel cost and fast charging availability may be valued differently under the contexts of buying and leasing. These extensions can provide more nuanced and in-depth understanding of people's preferences and behavior. Third, explore the potential of more types of business models which may be suitable for promoting innovative technologies and in particular EV, such as carsharing, vehicle-to-grid, etc. Finally, apart from consumers' preference for business models when they adopt a car, a more intriguing question under our specific context (EV adoption) is whether the provision of alternative business models can facilitate more EV sales and increase the market share; in other words, can business models shift consumers who previously would have bought conventional vehicles into EV adopters? The answer to this question is more relevant for public policy making since it helps to reach the goal of EV promotion and reducing the sustainability impact of road transport.

Declarations of interest

None.

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Appendix. Example of the full display of the 2nd and 3rd questions of a choice task (translated from Dutch)

Assume you can choose from the following three cars:

Attributes	Conventional vehicle	Battery electric vehicle (BEV)	Plug-in hybrid vehicle (PHEV)
Fuel cost	€13 per 100 km	**€2** per 100 km	**€4** per 100 km
Driving range with full fuel tank/battery	600km	**450km**	Electric range: **30km** Total range: **630km**
Fast charging station density		**On highway: one station every 100 km** **In cities:** Within **10 minutes** ride from the often visited locations	
Fast charging duration(till 80% of battery capacity)		**20 minutes**	
Governmental **incentive policies**	None	**Free public parking**	None
Number of days per year that you can make additional use of conventional car	n.a.	**14 days** per year	n.a.
Your previous choice: [X]	[X]Conventional vehicle €24000	Battery electric vehicle €33800	Plug-in Hybrid vehicle €29000

2. Now for **battery electric vehicle, you can choose to buy the car body only and lease the battery pack for a fixed payment per month. The price of the car body and the monthly leasing payment of the battery pack are listed below. Which car will you choose?**

Purchase	Battery lease
I keep my previous choice	Battery electric vehicle €28800 +€80 per month for maximum milage of 15.000km per year, 5 cent per extra km

a) Second question

Assume you can choose from the following three cars:

Attributes	Conventional vehicle	Battery electric vehicle (BEV)	Plug-in hybrid vehicle (PHEV)
Fuel cost	€13 per 100 km	**€2** per 100 km	**€4** per 100 km
Driving range with full fuel tank/battery	600km	**450km**	Electric range: **30km** Total range: **630km**
Fast charging station density		**On highway: one station every 100 km** **In cities:** Within **10 minutes** ride from the often visited locations	
Fast charging duration(till 80% of battery capacity)		**20 minutes**	
Governmental **incentive policies**	None	**Free public parking**	None
Number of days per year that you can make additional use of conventional car	n.a.	**14 days** per year	n.a.
Your previous choice: [X]	Conventional vehicle €24000	[X] Battery electric vehicle €28800 +€80 per month for maximum mileage of 15.000km per year, 5 cent per extra km	Plug-in Hybrid vehicle (PHEV) €29000

3. Suppose you can also **lease** one of the three cars. The **monthly lease fee** for these three cars are listed below. **Would you like to lease one of these three cars** Or will you keep your previous choice?

	Private lease for maximum mileage of **15.000km** per year, **10 cent** per extra km		
I keep my previous choice	Conventional vehicle €377 per month	Battery electric vehicle €533 per month	Plug-in Hybrid vehicle (PHEV) €473 per month

b) Third question

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