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The Effects of Life Course Events on Car Ownership and Sustainable Mobility Tools Adoption Decisions: Results of an Error Component Random Parameter Logit Model

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Abstract: Life course events can change household travel demand dramatically. Recent studies of car ownership have examined the impacts of life course events on the purchasing, replacing, and disposing of cars. However, with the increasing diversification of mobility tools, changing the fleet size is not the only option to adapt to the change caused by life course events. People have various options with the development of sustainable mobility tools including electric car, electric bike, and car sharing. In order to determine the impacts of life course events on car ownership and the decision of mobility tool type, a stated choice experiment was conducted. The experiment also investigated how the attributes of mobility tools related to the acceptance of them. Based on existing literature, we identified the attributes of mobility tools and several life course events which are considered to be influential in car ownership decision and new types of mobility tools choice. The error component random parameter logit model was estimated. The heterogeneity across people on current car and specific mobility tools are considered. The results indicate people incline not to sell their current car when they choose an electric bike or shared car. Regarding the life course events, baby birth increases the probability to purchase an additional car, while it decreases the probability to purchase an electric bike or joining a car sharing scheme. Moreover, the estimation of error components implies that there is unobserved heterogeneity across respondents on the sustainable mobility tools choice and the decision on household's current car.

Keywords: life course events; car ownership; error component model; electric car; car sharing

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1. Introduction

For decades, car ownership has been an important topic in transportation considering its close tie with the general urban problems, i.e., congestion, energy consumption, and pollution. Understanding the decision-making mechanism of individuals on their car ownership is essential for urban planners and policy makers.

The decision related to a car is usually a mid-term to long-term decision, which is often treated as a part of life choices linking to one's key events over a life course, such as job change, house (re)locations. Life course events may trigger the change of people's need for a car, thus influencing the level of car ownership and travel behavior in general. However, with a relatively thin consideration of urban transition as a context, the majority of existing studies have investigated the impact of life course events on the ownership of conventional cars only. Analyzing the impacts of life course events without considering car sharing, electric cars (EVs), and electric bikes may be fragmentary because mobility options nowadays are diversified with increasing applications of shared and/or electric tools whereas households have more options to cope with the change in their travel needs. For instance, car sharing that provides users the flexibility and accessibility of private cars, could induce people to sell their cars or avoid purchasing a car [1]. Moreover, electric bikes that have grown rapidly in recent years can potentially cover individuals' travel needs, leading to a modal shift away from conventional cars [2,3]. In addition, people can also purchase an EV as a substitute for a conventional car due to energy and environmental considerations.

In fact, the travel demand is highly dynamic in terms of people's life stages. With the emergence of sustainable mobility tools, the change in travel needs caused by life course events do not have to be satisfied by a conventional car only [4,5]. In some situations, these travel needs may be better matched with sustainable mobility tools instead of a conventional car. For example, if the changed travel demands by car caused by life course events is not constant and/or slight, e.g., living together with a partner who needs a car for travelling maximum once per week, the household can choose car sharing instead of purchasing a conventional car. In a case where the commuting time of an electric bike is acceptable due to a job change, people may adopt an electric bike for commuting instead of a car. Therefore, it seems highly necessary to investigate the impacts of life course events on car ownership by taking into account the new mobility options, such as car sharing, EVs, and electric bike.

Since knowledge about the impact of life course events on car ownership considering these sustainable mobility tools is limited, this paper investigates how life course events affect car possession and the adoption of sustainable mobility tools with particular emphasis on sustainable mobility tools including electric mobility and car sharing. Most existing studies about the impact of life course events on car possession rely on RP (revealed preference) data. However, car sharing and electric mobility are emerging products, implying such data are scarce for these emerging transportation modes. Therefore, in this study, the data collected from a stated choice experiment are used. Respondents can adopt to their changing travel needs caused by key life course events by choosing not only conventional cars but also the sustainable mobility tools. To the best of our knowledge, this is the first endeavor to incorporate life course events in a stated choice experiment. With the stated choice experiment, the direct effect of life course events is captured because the choice scenarios get rid of any possible disturbances of a context of historical decisions such as the macroeconomic environment.

In this paper, the existing literature related to the influence of life course events on car ownership and people's decisions on the sustainable mobility tools is discussed in Section 2. The experimental design and data collection are presented in Section 3. In Section 4, an error component random parameter logit model is proposed. Then the estimated results are presented and discussed. Section 6 summarizes this study and provides a discussion.

2. Literature Review

There is a vast body of literature dedicated to investigating car ownership including the number of cars in the household, car type, and car usage. Several studies [6,7] have discussed the vast body of literature comprehensively. Considering the context of the current study, this review firstly examined the various methodological approaches and the conclusion on the impact of life course events on car ownership. Then, previous studies focusing on the factors that impact the adoption of electric mobility and car sharing were discussed.

2.1. The Impact of Life Course Events on Car Ownership

Life course events have been viewed as internal forces that lead to changes in car ownership [8]. As the probabilities of car transactions may shift with interval time, the hazard-based models have been one type of the most commonly used method. For example, Beige and Axhausen [9] applied a hazard model focusing on the change in car availability to model the impacts of changes in employment and residence on the time elapsed between the change in car availability using life trajectory data. Changes in residence, education, and employment were found to increase the probability of changes in car ownership. On the basis of the hazard model, the competing risks model, which considered the type of car transactions, was applied in several studies [10–12]. The influence of changes in household size, education, employment, and house type has been analyzed and estimated using revealed preference data in these studies. They indicated the life course events related to the household composition, job location, and employment were all found to have statistically significant impacts on the probability of car transactions for replacing, purchasing, and disposing a car.

Although the hazard-based model can investigate the impact of life course events over time, it needs the assumption of the distribution of baseline hazard, which is difficult to specify. To analyze the interdependence between life course events and the mobility decision with fewer assumptions, the machine learning approach, including Bayesian belief network and CHAID, was used. Several studies [13–15] investigated the relationships between the changes in car ownership, residents' location, household structure, and employment.

The logit model is another approach that previous studies had used. Yamamoto [11] investigated the impact of life course events on car ownership using the multinomial logit model. The decrease, increase, and no change in the number of cars were considered as choice alternatives. The results showed that changes in the number of drivers and moving have a statistically significant impact on car ownership. Oakil, Ettema, Arentze, and Timmermans [16] analyzed the relations between changes in car ownership and life course events and estimated a mixed logit model using life trajectory data. To summarize, the existing studies focus on the impact of life course events on changes in car ownership using revealed preference data. The sustainable mobility tools have rarely been incorporated.

2.2. The Choice of Sustainable of Mobility Tools

People have more options of mobility tools nowadays, which could be attributed to the development of mobility tools. Household ownership of mobility tools becomes more diversified with the use of EV, car sharing, and electric bike. These sustainable mobility tools have a substitute effect on the conventional car. The factors that impact the preference for these sustainable mobility tools and how they influence ownership of conventional car have aroused intense scholarly interest.

In terms of the preference for EV, the factors that impact EVS adoption have been discussed for decades. The electric vehicle was compared with the conventional car (gasoline car) in these experiments to evaluate its substitution effect on the conventional car. Most of these studies conducted a stated choice experiment, which provided hypothetical choice scenarios, including the attributes of conventional car and EV. The data collected were estimated using the logit model. The factors that were found to have impacts can be classed into three categories. First, the car-related factors that were found to have an impact on the adoption of EV. Hoen and Koetse [17], for example, examined the influences of the purchase price, operation cost, maintenance cost, and the driving range on EV adoption with a stated choice experiment. The results showed most of these variables have statistically significant effects on the preference on EV. Next, the policy and public charging service-related factors have also been discussed. Several studies [18,19] found that policy incentives and public charging services had significant effects on the acceptance of EV, while other studies [20–22] did not find strong enough evidence on the effects of these factors. Moreover, the impacts of consumer-related attributes, including socio-demographics, psychological factors, and social influence have also been examined in previous studies [23–25]. The typical finding is that the acceptance of the electric car is impacted by socio-demographics, psychological factors, and social influence.

Regarding the electric bike, the adoption rate is influenced by three types of factors: socio-demographics, latent attitudes, and electric bike's attributes. Johnson and Rose [26] investigated the decision making process of purchasing an electric bike. They found that socio-demographics and environment concerns have statistically significant impacts on electric bike purchases. Jones, Harms, and Heinen [27] examined the motivations of the early adopters of electric bike in Austria. The results indicated attitudes on the environment and new technology influenced households' motivation to use an electric bike. They also found that the battery performance and driving range can attract people to use electric bikes. Moreover, an electric bike was considered to be a substitute for a conventional car and thus had an impact on car usage. The substitution effect has been proved by other studies from the UK [27], Australia [26], and China [28]. In above studies, electric bikes appeared to be used as a replacement transport mode for cars. Considering electric bikes are more appropriate for some trips, it is reasonable to hypothesize that at some point, electric bikes could cope with the changes in travel demand better than conventional cars.

Similar to EV and electric bikes, the factors impacting the preference for car sharing are socio-demographics, psychological factors, and the characteristics of car sharing. For example, the impacts of latent attitudes on car sharing have been investigated using a hybrid choice model [29]. The results showed the preferences on car sharing are impacted by latent attitudes about pro-environmental preferences, the symbolic value of cars, and privacy seeking. The savings related to using car sharing instead of a conventional car have been found to increase households' preference to join a car sharing scheme [30]. Moreover, the impact of car sharing on household car ownership has been discussed in several studies. Firnkorn and Müller [31] indicated that car-sharing systems could contribute to reducing private car ownership in cities using data from an interview about respondents' acceptance of car sharing. Le and Polak [32] focused on the perception of car sharing users and presented an analysis about the impact of car sharing on car ownership. The results showed more than 30% of car sharing users decided not to buy a car and more than 15% of car sharing users have sold (or could soon sell) their cars. Although the impact of car sharing on car ownership has been investigated extensively, relatively few studies have examined the impact of life cycle events on the decision of car sharing.

3. Experiment Design and Data Collection

To analyze households' willingness to change their vehicle holdings and adopt sustainable mobility tools considering the effects of various life course events, a web-based stated choice experiment was conducted. The survey consists of two main parts. The first part collects general information of households, respondents were asked to provide information regarding the age of each household member, gender, education, living situation, employment status of respondents and their partners, and household income. Then, a stated choice experiment was implemented. Five options were presented to respondents—conventional car, EV, electric bike, car sharing, and none of these. Beyond that, life course events were incorporated in the hypothetical scenarios of the decision on current car transactions and mobility tools purchasing. Respondents were asked to make a decision assuming a life course event happens to them. Both the types of life course events and the attributes of mobility tools varied across choice scenarios.

As for the types of life course events, Yamamoto [11] and Oakil et al. [16] suggested that changes in household composition, job, income, and residential address have effects on car ownership. Thus, we take into account these key life course events that a household may experience. The change of household structure and household members including living together with a partner, separation, baby birth, and child leaving home were selected. In addition, a change in occupation and income, such as change in job location, retirement, increase/decrease of household income were considered. The house relocation was also incorporated. No events occurring is the base for the life course events variable. To make the choice scenarios distinct and easy to get immersed, the life course events were explained in the description of the choice context.

For the context variable in the stated choice experiment, the characteristics of the hypothetical live events were provided to make sure respondents had adequate information to make decisions. The occupation and car ownership of the partner were described when respondents were asked to assume that they started living together. Whether the partner has a car and whether the partner has a job were presented. Similarly, the information about the service of public transport and the commuting distance were provided when changes in job locations were presented to respondents. The frequency of public transport was varied from 15 min to 60 min. The commuting distance was varied from 5 km to 105 km. The range was presented when the household income was assumed to change. For the house relocation, the weekly travel distance was varied from 200 km to 1000 km. The variables used to describe the life course events were listed in Table 1.

For the alternatives, each alternative was described by several attributes. The levels of these attributes were varied across choice scenarios. Based on previous studies about electric mobility and shared mobility, the attributes and levels were listed in Table 2. For the conventional car, the finance related variables including purchase price, operating cost and maintenance costs were used. For the electric vehicles, these variables were also selected. The levels of purchase price and maintenance cost were varied according to the levels of the corresponding conventional car. For instance, the purchase price of EV was set at a premium price from 15% higher to 45% higher. In addition to these variables, the variables related to driving range, charging speed, charging conveniency, and free parking policy were considered according to existing studies about electric vehicles [26]. For car sharing, maintenance cost, hourly rate, car availability, and time to the pickup point of car sharing were used. The purchase price, driving range, and maintenance cost were used to describe the electric bike.

To make sure the presented hypothetical life course events are relevant to a specific respondent, the hypothetical life course events were pre-selected based on the respondent's actual socio-demographic profile. To that end, respondents were categorized into 24 types based on their current socio-demographics. Life course events with no or low probability of happening for specific types of respondents were eliminated. For example, baby birth event can be assigned only if the respondent has a partner of a certain age. The event of living together was assigned only to respondents who are single. Then, a fractional factorial design which included 648 choice profiles was created. The choice profiles were designed using a D-efficient optimal design to minimize the possible standard error of the estimated parameters. Choice situations with realistic life course events were distributed randomly to respondents. The hypothetical life course events and choice sets characterized by the varied levels of attributes were shown to them. Each respondent was given 8 choice situations.

Table 1. Characteristics of life course events.

Life Course Events	Variables and Levels
Living together	Job of partner: has a job; has no job Car ownership of partner: has a car; has no car
Job relocation	Frequency of public transport: 15 min; 30 min; 60 min Commuting distance: 5 km; 15 km; 45 km; 75 km; 105 km
Income change	increase 20%; increase 10%; decrease 10%; decrease 20%;
House relocation	Weekly travel distance: 200 km; 500 km; 1000 km

The choice tasks included choices of mobility tools and decisions to sell or keep the current car in the household. To reduce the burden to recall the information of their current car again, the information filled in previous questions was invoked and presented to them. The life course event in each choice situation was marked in red to avoid being ignored. An example of the stated choice experiment of mobility tools is shown in Figure 1. Consequently, respondents had 10 options, as listed in Table 3.

Image that: You have a new job and your daily commuting distance (one-way) becomes 15 km; and public transport frequency is every 30 minutes.
How would you like to change your mobility option?

	Buy an electric car	Buy a regular car	Join car sharing	Buy an ebike	None
Purchase price (battery included)	58.500 Euro	45.000 Euro	-	1000 Euro	
Maintenance cost	165 Euro/Month	150 Euro/Month	20 Euro/Month	5 Euro/Month	
Operating cost	0.06 Euro/km	0.1 Euro/km	0.3 Euro/km	0.01 Euro/km	
Hourly rate	-	-	4 Euro/hour	-	
Free parking	Yes	No	No	Yes	
Driving range	450 km	600 km	600 km	80 km	
Access time	-	-	10 min	-	
Vehicle availability	100%	100%	60%	100%	
Average travel time to charging station from where you are	15 min	-	-	-	
Fast charging time per 100km	10 min	-	-	-	
Slow charging time per 100km	3 hour	-	-	-	
Charging opportunity	80%	-	-	-	
Bike lane	-	-	-	Yes	
Your Choice	○	○	○	○	○

Whether you would like to keep your current most used car?

		KEEP	SELL
This information is based on what you filled in before.	Maintence cost	2000 Euro/year	
	Mileage per year	10.000km/year	
	Production year	2015	
Your Choice		○	○

Figure 1. Example of a choice task.

The survey was conducted in the city of Weiz, which is located in the eastern part of Styria, Austria. This study focused on the adoption of sustainable mobility options that met the local citizens' interests in these mobility options. The city of Weiz has the desire to be energy self-sufficient. It is the first municipality in Austria that sets the city on natural energy. Therefore, collecting data in Weiz was appropriate.

Weiz has a population of more than 11,000 and an area of 17.5 km^2. The city of Weiz is an industrial, school, and commercial town. Over 8000 people are currently commuting to work and around 2500 schoolchildren are commuting to the city. Although the commuting distance in Weiz is short, using cars for short distances leads to traffic jams in peak hours. The share of public transport was less than 5% in 2017. The data were collected in October 2017 using a web-based questionnaire system. Data collection was conducted at household level. There are fewer than 6000 households in Weiz. We invited respondents from 425 households to answer the questionnaire. Of the 425 respondents invited, 265 completed the questionnaire. After data cleaning and reliability checks of the responses, data from 203 respondents remained for analysis, implying the response rate of 47.8%.

The frequency distribution of socio-demographic characteristics was listed in Table 4. It showed that the number of males and females was almost the same. Regarding their living situation, more than one-third of the respondents lived with a partner and a child, while 26.7% lived with their partner without children and about 16% were single. The majority of the respondents had a full-time job, while about 20% had a part-time job. As for their home ownership, nearly one-third of the respondents rented a house, while the rest owned a house. Households living in apartments accounted for nearly 40% of the sample. More than 46% of the respondents lived in a detached house. Households living in terraced or semi-detached houses constituted a relatively small proportion. The majority of the respondents lived in houses of between 60 and 150 square meters. Around 43% of the respondents had a gross annual income between 25,000 and 50,000 euros, while 28% had a higher income. The rest had a relatively low income (less than 25,000 euros/year). As for car ownership, nearly 91% of the respondents had a car. However, only 11% of the households owned an electric vehicle. Less than 9% respondents had electric bikes.

Table 2. Selected attributes and attribute levels of mobility tools.

	Attributes	Attribute Levels
Conventional car	Purchase price (euros)	15,000; 30,000; 45,000
	Maintenance costs (euros/month)	150; 250
	Operating costs (euros/km)	0.1; 0.12
EV	Purchase price (euros)	15%; 30%; 45% (higher than CV)
	Maintenance costs (euros/month)	10%; 20% (higher than CV)
	Operating costs (euros/km)	0.04; 0.06
	Free parking	always; on non-peak hours; no
	Driving range (km)	150; 300; 450
	Average travel time to charging station (min)	5; 10; 15
	Fast charging time per 100 km (min)	5; 10; 15
	Slow charging time per 100 km (hour)	1.5; 3
	Probability of charging without waiting	60%; 80%
Electric bike	Purchase price (euros)	1000; 2000; 3000
	Maintenance costs (euros/month)	5; 10
	Free parking	yes; no
	Driving range (km)	40; 80
	Bike lane availability	yes; no
Car sharing	Maintenance costs (euros/month)	0; 10; 20
	Operating costs (euros/km)	0.2; 0.3
	Hourly rate (euros/hour)	4; 6
	Access time (min)	5; 15; 25
	Vehicle availability	60%; 80%; 100%

Table 3. The alternatives of each choice sets.

Choice of Mobility Tools	Decision of Current Car	Alternatives
buy an EV	keep current car	Keep + EV
buy an EV	sell current car	Sell + EV
buy a conventional car	keep current car	Keep + CV
buy a conventional car	sell current car	Sell + CV
buy an E-bike	keep current car	Keep + E-bike
buy an E-bike	sell current car	Sell + E-bike
join a car sharing scheme	keep current car	Keep + sharing
join a car sharing scheme	sell current car	Sell + sharing
none	keep current car	Sell
none	sell current car	Keep current

Table 4. Descriptive statistics of the sample.

Characteristics	Levels	Percentage (%)	Characteristics	Levels	Percentage (%)
Gender	Male	49.3	Living situation	Single	16
	Female	50.7		Single parent with children	5.6
Education	Primary school	33.6		Couple without children	26.7
	Secondary school	27.6		Couple with children	35.3
	College education or higher	36.4		Living with parents	13
	Other	2.4		Other	3.3
Income	Lower than 25,000 euros/year	28.8	Work	No work	6.3
	25,000–50,000 euros/year	43.2		Full-time paid work	65.4
	50,000–75,000 euros/year	20.1		Part-time paid work	20.3
	75,000–100,000 euros/year	4.1		Full-time unpaid work	7.6
	Higher than 100,000 euros/year	3.8		Part-time unpaid work	0.4
Mobility tools ownership	Vehicles	91.1			
	Electric vehicles	10.8			
	Electric bikes	9.4			

4. Method

In the decision-making process of car ownership and car type when life course events happen, people may differ in terms of their consumption habits and lifestyle towards sustainable mobility tools. Taste differences are typically treated as unobserved heterogeneity among respondents in random parameter discrete choice models. Assuming the utility of a household n ($n = 1 \ldots N$) for alternative j is a function of a vector of variable $\boldsymbol{X}$, which describes the household, the alternatives, and choice context, the utility can be written as:

$$U_{nj} = \beta_{j0} + \boldsymbol{\beta}_i \boldsymbol{X}_{nj} + \varepsilon_{nj} \tag{1}$$

where U_{nj} is the utility of alternative j for household i, $\boldsymbol{X}_{nj}$ is a $(K \times 1)$ vector of the explanatory variables which include the life course events, context variables, socio-demographics, and the attributes related to alternative, j. K is the number of explanatory variables. The $(1 \times K)$ vector $\boldsymbol{\beta}_n$ consists of the parameters of the corresponding variables. ε_{nj} is a random error term which follows an IID Gumbel distribution. β_{j0} is the alternative specific constant. Because the number of variables is high, only the alternative specific constants β_{j0} were considered as random parameters. β_{j0} is assumed to follow a standard normal distribution. The household-specific parameter β_{nj0} can be expressed as follows:

$$\beta_{nj0} = \overline{\beta}_{j0} + \sigma_j \, \nu_n \tag{2}$$

here $\overline{\beta}_{j0}$ is the mean, ν_n is a household-specific random term follows a standard normal distribution with zero mean and standard deviation 1. σ_j is standard deviation of β_{j0}.

In addition to the random parameters, heterogeneity can be further decomposed into components associated with nested alternatives. As mentioned in Chapter 3, the choice set in the stated choice experiment consists of 10 alternatives. Each choice task includes the decision about the current car and the decision about sustainable mobility tools. The heterogeneity underlying these two decisions may affect the utility of alternatives. The possible correlations between the alternatives are depicted in Figure 2.

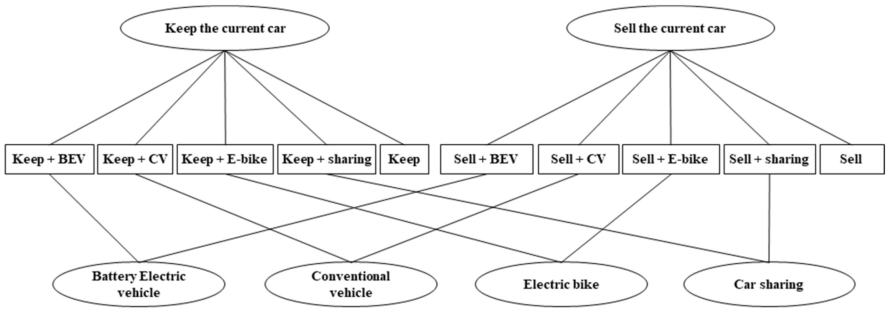

Figure 2. Correlations between the alternatives.

To consider the relationship between alternatives, the error component random parameter logit model has been used to reflect the structure of the alternatives. Therefore, the error components are added to the utilities of the nested alternatives to decompose the unobservable components of the utilities. The error components are assumed to be normally distributed. In addition, panel effects should be considered since each respondent completes eight choice tasks in the choice experiment. Thus, the utility function takes the form:

$$U_{ij} = \beta_{0j} + \boldsymbol{\beta}_n \boldsymbol{X}_{nj} + \sum_{m \in M} d_j^m \delta^m E_n^m + \varepsilon_{nj} \tag{3}$$

where $E_n^m (m = 1, \ldots M)$ are alternative-specific random error terms, M is the number of error components, $E_n^m \sim \mathrm{N}[0,1]$, δ^m is the corresponding standard deviation of error component m. d_j^m is an indicator variable, which is equal to 1 if E_n^m contributes to the utility of alternative j and 0 otherwise. These error components are incorporated to consider any unobserved heterogeneity underlying the specific type of mobility tool and the specific decision. Here, four error components, E_n^1, E_n^2, E_n^3, and E_n^4 are specified to denote the grouped error components for the EV, conventional car, car sharing and electric bike, respectively. Two error components, E_n^5 and E_n^6, are specified for the decision of keeping the current car and selling the current car. The utility function for each alternative is given by:

$$\begin{array}{ll}
\text{Keep} + \text{EV}: & U_{n1} = \beta_{01} + \boldsymbol{\beta}_n \boldsymbol{X}_{n1} + \delta^1 E_n^1 + \delta^5 E_n^5 + \varepsilon_{n1} \\
\text{Keep} + \text{CV}: & U_{n2} = \beta_{02} + \boldsymbol{\beta}_n \boldsymbol{X}_{n2} + \delta^2 E_n^2 + \delta^5 E_n^5 + \varepsilon_{n2} \\
\text{Keep} + \text{car sharing}: & U_{n3} = \beta_{03} + \boldsymbol{\beta}_n \boldsymbol{X}_{n3} + \delta^3 E_n^3 + \delta^5 E_n^5 + \varepsilon_{n3} \\
\text{Keep} + \text{e-bike}: & U_{n4} = \beta_{04} + \boldsymbol{\beta}_n \boldsymbol{X}_{n4} + \delta^4 E_n^4 + \delta^5 E_n^5 + \varepsilon_{n4} \\
\text{Keep}: & U_{n5} = \delta^5 E_n^5 + \varepsilon_{n5} \\
\text{Sell} + \text{EV}: & U_{n6} = \beta_{06} + \boldsymbol{\beta}_n \boldsymbol{X}_{n6} + \delta^1 E_n^1 + \delta^6 E_n^6 + \varepsilon_{n6} \\
\text{Sell} + \text{CV}: & U_{n7} = \beta_{07} + \boldsymbol{\beta}_n \boldsymbol{X}_{n7} + \delta^2 E_n^2 + \delta^6 E_n^6 + \varepsilon_{n7} \\
\text{Sell} + \text{car sharing}: & U_{n8} = \beta_{08} + \boldsymbol{\beta}_n \boldsymbol{X}_{n8} + \delta^3 E_n^3 + \delta^6 E_n^6 + \varepsilon_{n8} \\
\text{Sell} + \text{e-bike}: & U_{n9} = \beta_{09} + \boldsymbol{\beta}_n \boldsymbol{X}_{n9} + \delta^4 E_n^4 + \delta^6 E_n^6 + \varepsilon_{n9} \\
\text{Sell}: & U_{n10} = \delta^6 E_n^6 + \varepsilon_{n10}
\end{array} \tag{4}$$

The probability of the random parameters error component model is given by

$$P_{nt}(j|\beta_{j0}, E_n^m) = \frac{exp(\beta_{j0} + \boldsymbol{\beta}_n \boldsymbol{X}_{nj} + \sum_{m \in M} d_j^m \delta^m E_n^m)}{\sum_{j=1}^{J} exp(\beta_{j0} + \boldsymbol{\beta}_n \boldsymbol{X}_{nj} + \sum_{m \in M} d_j^m \delta^m E_n^m)} \tag{5}$$

$$P_{njt} = \int_{\beta_{j0}} \int_{E_n} P_{nj}(j|\beta_{j0}, E_n^m) f(E_n^m) f(\beta_{j0}) dE_n^m d\beta_{j0} \tag{6}$$

The likelihood function L of the error component random parameter model can be formulated as:

$$L = \prod_{n=1}^{N} \int_{\boldsymbol{\beta}_i} \int_{\boldsymbol{E}_i} P_n(j|\beta_{j0}, E_n) f(E_n) f(\beta_{j0}) dE_n d\beta_{j0} \tag{7}$$

The integral in the likelihood function was approximated using a simulation method. Therefore, simulated maximum likelihood was used to estimate the parameters. The random parameter and the error components were assumed to follow normal distributions. To evaluate the integrals in the log-likelihood function, Halton draws were used.

5. Results

The mixed logit model and the error component random parameter logit model were estimated using *Nlogit* software. The number of Halton draws was selected based on the log-likelihood value. The mixed logit model with 1500 draws, which has the highest log-likelihood value of −3401.53, was chosen. For the error component random parameter logit model, 2000 Halton draws were chosen since the goodness of fit did not improve when further increasing the number of draws. The estimation results are listed in Table A1 in Appendix A. It shows that the log-likelihood improved from −4024.75 to −3332.10 from the MNL model to the error component random parameter logit model. It is shown that the error component random parameter logit model improves the adjusted Rho-squared from 0.162 to 0.388. It also has better goodness-of-fit than the random parameter logit model. The next three sub-sections focus on the interpretation of the results of the error component random parameter logit model.

5.1. Attributes of Alternatives

Results show that all alternative-specific constants are negative, implying that keeping the current car is the most preferred option (reference alternative) when everything else is equal. It indicates that life course events do not always lead to a change in car ownership. The costs (time, money, and convenience) of changing car ownership in general make respondents reluctant to choose a sustainable mobility tool [33–36]. As for the choice of the mobility tool, people prefer a conventional car over an EV, in case they replace the current car or purchase an additional car. This finding is as expected and in line with previous research because EVs are relatively new and have not been widely accepted. The constant of "Keep current car and purchase an electric bike" is larger than that of "Sell current car and purchase an electric bike", indicating people are inclined to keep their current car when they choose an electric bike. Similarly, for car sharing, the probability of "Keep current car and join a car sharing scheme" is higher than the probability of "Sell current car and join a car sharing scheme". As for the estimated random parameters, the standard deviations of the alternatives purchasing an additional EV, joining car sharing scheme, and selling the current car are significant, which implies unobserved heterogeneity exists.

For the attributes of EV, the results indicate that the utility of EV was significantly impacted by the purchase price. Respondents' propensity to purchase an EV declines with increasing price. The decrease is steeper when the price of an EV is 30% to 45% more expensive than the price of a conventional car. In addition, the coefficient of price in the alternative of "Keep current car and purchase an EV" is lower than the price coefficient of "Sell the current car and purchase an EV", which suggests that people are more sensitive to price when they purchase an EV as an additional car.

Another cost attribute, operating costs, is found to have a negative and statistically significant effect on EV adoption decisions. Moreover, the effect of operating costs of EV is larger when respondents "Sell the current car and purchase an EV" than when respondents "Keep current car and purchase an EV". This might be because the EV will be used more frequently when it is a replacement of the current car.

In addition, driving range is found to significantly affect the decision to choose an EV. The intention to purchase an EV increases with decreasing range. The parameter for a range of 300 km is negative for the alternative of "Sell the current car and purchase an EV", while positive for "Keep current car and purchase an EV". This difference indicates that people prefer to have a longer driving range when they purchase an EV as their only car.

Charging speed is another important factor that affects the choice of EV. Compared to the slow charging speed (0.261), the fast-charging speed (0.898) has a larger parameter. It indicates that people attach greater weight to fast charging speed than slow charging speed when choosing an EV. As for the effect of charging infrastructure, people are more likely to choose an EV when the travel time to the nearest charging station is less than 5 min. In addition, a 100% probability of charging without waiting has a significant influence on the choice of an EV. Regarding the free parking policy, results show that the free parking policy has an insignificant effect on EV adoption.

In case of the choice of a conventional car, price and maintenance costs are found to have a significant and negative effect on the adoption of conventional cars. Similar to the results of EV, the effects of operating costs are higher when respondents "Sell the current car and purchase an EV" than when respondents "Keep current car and purchase an EV". For the electric bike, price has a significant effect on the alternative "Keep current car and purchase an electric bike", while the effect is insignificant for the alternative "Sell current car and purchase an electric bike". This implies that the preference for replacing a conventional car with an electric bike is hardly influenced by the price of e-bikes. Shifting transportation mode from conventional car to electric bike is rarely caused by marking down the price of electric bikes, although a lower price may promote electric bikes as an additional mobility tool. In comparison, the driving range of e-bikes has a positive effect on electric bike adoption. The utility of electric bikes increases with increasing driving range.

For the alternative, "Keep current car and join a car sharing scheme", the utility decreases with increasing maintenance costs of current car in the household. The utility drops rapidly when the maintenance costs increase from 0 to 10 euro per month, while the effect for maintenance costs between 10 euro and 20 euro per month is small. Both hourly rate and operating costs have negative effects on the utility of car sharing. The impacts of hourly rate and operating costs when the car sharing is an additional mobility tool, is higher, than the impacts when the car sharing is a substitution of current car in the household. Another important factor that influences the utility of car sharing is the availability of shared cars. The result implies that the utility of car sharing increases when the availability of a car increases from 80% to 100%.

5.2. Current Car Attributes and Life Course Event Attributes

Table 4 also lists the coefficients for the current car and life course event attributes. The results show that people prefer to keep the current car when its maintenance costs are less than 1000 euro per year. Furthermore, the parameter for the maintenance costs of the current car for the alternative "Selling current car and purchasing an additional car" is significant and larger than the corresponding parameter for the alternative "Keeping current car". This result indicates that people are more sensitive to the maintenance costs of the current car when they sell their current car than when they keep it. As for the mileage per year of the current car, which is a measure of use intensity, a positive effect is found for selling the current car and purchasing an additional car but not for joining car sharing. The age of the current car has a positive effect on the utility of selling the current car.

As for life course events, baby birth increases the probability to purchase an electric vehicle or a conventional car. By contrast, it decreases the probability to purchase an electric bike and to join a car sharing scheme. People who live separately from their partner are more likely to replace their current car, instead of purchasing an additional car or just selling the current car. Unlike Oakil et al. [16], who suggest that retirement most likely leads to a reduction of car ownership, this study suggests that people are inclined to sell their current car and purchase other types of mobility tools, rather than only sell their current car. The results show that parameters for "Partner has a car" are negative for the alternative purchasing an additional mobility tools, which means that people were disinclined to purchase an additional car if the partner that they will live with has a car. In addition, the results show that people were more likely to replace or sell their current car if their partner had a car.

Partner having a job increases the probability of purchasing an additional car. While living with a partner who has a job, people prefer to purchase an additional car or replace current car in the household, rather than join a car sharing scheme or purchase an electric bike. The results imply that EV and conventional cars are more acceptable choices than electric bikes or joining a car sharing scheme when a partner has a job. The parameters of having a new job within 5 km are negative for the alternatives "Keep the current car and purchase an EV" and "Keep the current car and purchase a CV". The results imply that people are more likely to choose an electric bike when their commuting distance is shorter than 5 km. The commuting distance had positive impacts on the utility of purchasing a car. In addition, the convenience of public transportation had no significant effect on the choice of these sustainable mobility tools.

5.3. The Error Components

The results of the error components show that the standard deviation of EV and car sharing are statistically significant, implying these alternatives share the same error components. The standard deviation of selling the current car is statistically significant. These results imply the unobserved heterogeneity across respondents on the sustainable mobility tools. EV and car sharing are relatively new products, therefore, the decisions to choose them are not fully captured by the observed variables. The unobserved heterogeneities are associated with these two types of mobility tools. As for the decision on the current car, the results show the standard deviation of selling the current car is statically significant. It suggests the unobserved heterogeneity when making a decision on the current car. The results indicate the decision on the current car may not only be influenced by the attributes of the current car and the alternatives but also the individual consumption habits and lifestyle. These results show the "cross-nested structure" in the decision of mobility tools with the diversity of mobility tools market.

6. Conclusions and Discussion

The literature on examining the influence of life course events on car ownership is vast and numerous. These studies mainly focus on the number of cars and the decision on purchasing, replacing, disposing of cars. The sustainable mobility tools including EVs, electric bike, and car sharing have been growing rapidly in recent years. With the sustainable mobility tools, people do not have to cope with changing travel demands by changing the fleet size in the household. Therefore, the sustainable mobility tools should be considered in the analysis of the decision of car ownership and types of mobility tools. Most of the previous studies that have investigated the effects of life course events on a household's car ownership used revealed preference data, which are difficult to collect for sustainable mobility tools. Therefore, the study contributes to the existing literature by analyzing the impacts of life course events on the decision of car ownership with a stated choice experiment. Moreover, the effects of life course events on the preference of sustainable mobility tools that could be a substitute for the conventional car were investigated in this study. To consider the unobserved heterogeneity caused by the structure of the alternatives, this study uses an error component random parameter model. In the model, the alternatives that share one type of mobility tool or decision on the current car have the same corresponding error component. Results show that life course events have a significant but varied effect on the choice of sustainable mobility options. The variances for the random parameters and for the error components are both significant. The significant variances for random parameter and error component indicate that the unobserved heterogeneities are associated with the choice of specific mobility tool and the decision on the current car, which is not completely captured by the random parameters in the mixed logit model. A limitation of our work is the inability to consider the effect of people's latent attitude on sustainable mobility tools and lifestyle due to the limited sample size. This study provided an appropriate modeling approach to incorporate life course events and sustainable mobility options, considering the unobserved heterogeneity. The different effects of life course events on the preferences of mobility tools show that this article could be helpful in providing a precise simulation as it has considered the effects of life course events in addition to the attributes of mobility tools and socio-demographics.

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Appendix A

Table A1. Results of the error component random parameter logit model.

Attributes	Description	Coef.	*p*
Keep current car and purchase an EV			
Maintenance costs of current car	Less than 1000 euro per year	0.447	0.252
	More than 1000 euro per year	−0.447	0.252
Mileage per year	Less than 15,000 km	−2.306	0.000
	Mileage per year more than 15,000 km	2.306	0.000
Age of current car	Car age < 5 years	0.176	0.699
	Car age > 5 years	−0.176	0.699
Life course event	Separation	−0.430	0.847
	Baby birth	1.972	0.113
	Child leave	−3.456	0.475
	Losing job	−2.115	0.049
	Retirement	−1.017	0.474
	Living together with partner who has a car	−0.006	0.997
	Living together with partner without a car	0.006	0.997
	Living together with partner who has a job	0.982	0.597
	Living together with partner without a job	−0.982	0.597
	New job with commute distance of 5 km	−1.875	0.204
	New job with commute distance of 15 km	0.142	0.868
	New job with commute distance of 45 km	0.380	0.662
	New job with commute distance of 75 km	0.790	0.368
	New job with PT frequency every 15 min	−0.002	0.998
	New job with PT frequency every 30 min	−0.170	0.840
	New job with PT frequency every 60 min	0.172	
	Income change	0.927	0.861
Price	15% higher than CV	1.849	0.002
	30% higher than CV	1.157	0.028
	45% higher than CV	−3.005	
Maintenance costs	10% higher than CV	0.218	0.470
	20% higher than CV	−0.218	0.470
Operating costs	0.04 euro/km	0.248	0.095
	0.06 euro/km	−0.248	0.095
Driving range	150 km	−0.819	0.045

Table A1. *Cont.*

Attributes	Description	Coef.	*p*
	300 km	0.191	0.144
	450 km	0.628	
Fast charging speed per 100 km	5 min	0.898	0.042
	10 min	−0.065	0.893
	15 min	−0.833	
Slow charging speed per 100 km	1.5 h	0.261	0.378
	3 h	−0.261	0.378
Time to charging station	5 min	0.698	0.122
	10 min	0.325	0.533
	15 min	−1.023	
Probability of charging without waiting	60%	−0.624	0.063
	80%	0.624	0.063
Free-parking	Always	−0.028	0.961
	Peak hours only	0.091	0.807
	No	−0.063	
Keep current car and purchase an CV			
Maintenance costs of current car	Less than 1000 euro per year	0.094	0.738
	More than 1000 euro per year	−0.094	0.738
Mileage per year	Less than 15,000 km	−0.527	0.042
	Mileage per year more than 15,000 km	0.527	0.042
Age of current car	Car age < 5 years	−0.114	0.724
	Car age > 5 years	0.114	0.724
Life course event	Separation	1.232	0.247
	Baby birth	0.921	0.356
	Child leave	1.174	0.278
	Losing job	−0.493	0.551
	Retirement	−0.609	0.587
	Living together with partner who has a car	−1.485	0.251
	Living together with partner without a car	1.485	0.251
	Living together with partner who has a job	1.033	0.564
	Living together with partner without a job	−1.033	0.564
	New job with commute distance of 5 km	−2.110	0.085
	New job with commute distance of 15 km	0.204	0.815
	New job with commute distance of 45 km	0.753	0.338
	New job with commute distance of 75 km	0.700	0.356
	New job with PT frequency every 15 min	−0.160	0.754
	New job with PT frequency every 30 min	−0.030	0.959
	New job with PT frequency every 60 min	0.190	
	Income change	1.116	0.830
Price	15,000 euro	2.660	0.000
	30,000 euro	−0.835	0.029
	45,000 euro	−1.825	
Maintenance costs	150 euro/month	0.584	0.017
	250 euro/month	−0.584	0.017
Operating costs	0.1 euro/km	0.287	0.283
	0.12 euro/km	−0.287	0.283
Keep current car and purchase an electric bike			
Maintenance costs of current car	Less than 1000 euro per year	0.170	0.496
	More than 1000 euro per year	−0.170	0.496
Mileage per year	Less than 15,000 km	0.007	0.982
	Mileage per year more than 15,000 km	−0.007	0.982

Table A1. *Cont.*

Attributes	Description	Coef.	*p*
Age of current car	Car age < 5 years	0.015	0.950
	Car age > 5 years	−0.015	0.950
Life course event	Separation	1.317	0.422
	Baby birth	0.200	0.911
	Child leave	1.096	0.195
	Losing job	−0.450	0.619
	Retirement	1.764	0.029
	Living together with partner who has a car	−1.258	0.600
	Living together with partner without a car	1.258	0.600
	Living together with partner who has a job	0.091	0.972
	Living together with partner without a job	−0.091	0.972
	New job with commute distance of 5 km	1.237	0.063
	New job with commute distance of 15 km	1.243	0.138
	New job with commute distance of 45 km	0.009	0.994
	New job with commute distance of 75 km	−0.882	0.308
	New job with PT frequency every 15 min	−0.746	0.253
	New job with PT frequency every 30 min	0.229	0.759
	New job with PT frequency every 60 min	0.517	
	Income change	−3.900	0.540
Price	1000 euro	0.926	0.021
	2000 euro	0.268	0.468
	3000 euro	−1.194	
Maintenance costs	5 euro/month	−0.233	0.386
	10 euro/month	0.233	0.386
Driving Range	80 km	0.438	0.091
	40 km	−0.438	0.091
Parking facilities	Yes	0.179	0.489
	No	−0.179	0.489
Bike lane	Yes	0.277	0.266
	No	−0.277	0.266
Keep current car and join a car sharing scheme			
Maintenance costs of current car	Less than 1000 euro per year	0.383	0.660
	More than 1000 euro per year	−0.383	0.660
Mileage per year	Less than 15,000 km	−0.118	0.859
	Mileage per year more than 15,000 km	0.118	0.859
Age of current car	Car age < 5 years	0.079	0.899
	Car age > 5 years	−0.079	0.899
Life course event	Separation	1.306	0.413
	Baby birth	−0.867	0.625
	Child leave	−1.227	0.539
	Losing job	−1.554	0.408
	Retirement	−1.169	0.559
	Living together with partner who has a car	−0.928	0.620
	Living together with partner without a car	0.928	0.620
	Living together with partner who has a job	0.321	0.865
	Living together with partner without a job	−0.321	0.865
	New job with commute distance of 5 km	0.576	0.480
	New job with commute distance of 15 km	0.614	0.670
	New job with commute distance of 45 km	−0.455	0.637
	New job with commute distance of 75 km	−0.171	0.898
	New job with PT frequency every 15 min	−0.478	0.529
	New job with PT frequency every 30 min	0.069	0.931
	New job with PT frequency every 60 min	0.409	
	Income change	−1.885	0.792
Maintenance costs	0 euro/month	1.013	0.066
	10 euro/month	−0.491	0.520

Table A1. *Cont.*

Attributes	Description	Coef.	p
	20 euro/month	−0.522	
Operating costs	0.2 euro/km	0.103	0.107
	0.3 euro/km	−0.103	0.107
Hourly rate of car sharing	4 euro/hour	−0.351	0.082
	6 euro/hour	0.351	0.082
Time to pick up point	5 min	0.503	0.259
	10 min	0.471	0.339
	15 min	−0.974	
Availability	60%	−0.849	0.320
	80%	−0.232	0.719
	100%	1.080	
Sell current car and purchase an EV			
Maintenance costs of current car	Less than 1000 euro per year	−0.896	0.053
	More than 1000 euro per year	0.896	0.053
Mileage per year	Less than 15,000 km	−0.596	0.127
	Mileage per year more than 15,000 km	0.596	0.127
Age of current car	Car age < 5 years	−1.229	0.014
	Car age > 5 years	1.229	0.014
Life course event	Separation	1.457	0.347
	Baby birth	0.796	0.570
	Child leave	−1.108	0.824
	Losing job	−0.343	0.815
	Retirement	0.859	0.486
	Living together with partner who has a car	0.847	0.724
	Living together with partner without a car	−0.847	0.724
	Living together with partner who has a job	1.663	0.505
	Living together with partner without a job	−1.663	0.505
	New job with commute distance of 5 km	−1.490	0.280
	New job with commute distance of 15 km	−0.115	0.910
	New job with commute distance of 45 km	0.816	0.415
	New job with commute distance of 75 km	0.866	0.478
	New job with PT frequency every 15 min	−0.332	0.747
	New job with PT frequency every 30 min	−0.159	0.841
	New job with PT frequency every 60 min	0.491	
	Income change	2.570	0.605
Price	15% higher than CV	1.411	0.005
	30% higher than CV	0.821	0.051
	45% higher than CV	−2.232	
Maintenance costs	10% higher than CV	0.205	0.549
	20% higher than CV	−0.205	0.549
Operating costs	0.04 euro/km	0.543	0.092
	0.06 euro/km	−0.543	0.092
Driving Range	150 km	−1.947	0.001
	300 km	−0.303	0.599
	450 km	2.250	
Fast charging speed per 100 km	5 min	1.074	0.018
	10 min	0.144	0.825
	15 min	−1.218	
Slow charging speed per 100 km	1.5 h	0.370	0.268
	3 h	−0.370	0.268
Time to charging station	5 min	0.266	0.604
	10 min	0.128	0.783
	15 min	−0.394	
Probability of charging without waiting	60%	−0.794	0.012

Table A1. *Cont.*

Attributes	Description	Coef.	*p*
	80%	0.394	0.000
Free-parking	Always	0.399	0.425
	Peak hours	0.068	0.857
	No	−0.467	
Sell current car and purchase an CV			
Maintenance costs of current car	Less than 1000 euro per year	−0.784	0.009
	More than 1000 euro per year	0.784	0.009
Mileage per year	Less than 15,000 km	0.932	0.010
	Mileage per year more than 15,000 km	−0.932	0.010
Age of current car	Car age < 5 years	−1.788	0.001
	Car age > 5 years	1.788	0.001
Life course event	Separation	1.539	0.174
	Baby birth	0.692	0.583
	Child leave	0.014	0.991
	Losing job	−0.173	0.855
	Retirement	0.721	0.472
	Living together with partner who has a car	0.472	0.768
	Living together with partner without a car	−0.472	0.768
	Living together with partner who has a job	0.404	0.858
	Living together with partner without a job	−0.404	0.858
	New job with commute distance of 5 km	−0.501	0.504
	New job with commute distance of 15 km	0.043	0.962
	New job with commute distance of 45 km	−0.211	0.825
	New job with commute distance of 75 km	0.093	0.917
	New job with PT frequency every 15 min	−0.237	0.670
	New job with PT frequency every 30 min	−0.447	0.467
	New job with PT frequency every 60 min	0.684	
	Income change	−1.907	0.756
Price	15000 euro	2.231	0.000
	30000 euro	−0.788	0.032
	45000 euro	−1.443	
Maintenance costs	150 euro/month	0.460	0.066
	250 euro/month	−0.460	0.066
Operating costs	0.10 euro/km	0.479	0.094
	0.12 euro/km	−0.479	0.094
Sell current car and purchase an electric bike			
Maintenance costs of current car	Less than 1000 euro per year	−0.789	0.023
	More than 1000 euro per year	0.789	0.023
Mileage per year	Less than 15,000 km	1.234	0.022
	Mileage per year more than 15,000 km	−1.234	0.022
Age of current car	Car age < 5 years	−0.831	0.065
	Car age > 5 years	0.831	0.065
Life course event	Separation	−0.474	0.834
	Baby birth	0.306	0.868
	Child leave	1.128	0.342
	Losing job	0.806	0.455
	Retirement	1.757	0.176
	Living together with partner who has a car	0.648	0.901
	Living together with partner without a car	−0.648	0.901
	Living together with partner who has a job	0.226	0.967
	Living together with partner without a job	−0.226	0.967
	New job with commute distance of 5 km	0.981	0.338
	New job with commute distance of 15 km	0.775	0.506

Table A1. *Cont.*

Attributes	Description	Coef.	*p*
	New job with commute distance of 45 km	−0.243	0.860
	New job with commute distance of 75 km	0.780	0.649
	New job with PT frequency every 15 min	−0.138	0.865
	New job with PT frequency every 30 min	−0.486	0.609
	New job with PT frequency every 60 min	0.624	
	Income change	−3.247	0.611
Price	1000 euro	0.392	0.378
	2000 euro	−0.202	0.663
	3000 euro	−0.190	
Maintenance costs	5 euro/month	0.298	0.436
	10 euro/month	−0.298	0.436
Driving range	80 km	0.696	0.048
	40 km	−0.696	0.048
Parking facilities	Yes	−0.006	0.989
	No	0.006	0.989
Bike lane	Yes	0.196	0.579
	No	−0.196	0.579
Sell current car and join a car sharing scheme			
Maintenance costs of current car	Less than 1000 euro per year	−0.719	0.212
	More than 1000 euro per year	0.719	0.212
Mileage per year	Less than 15,000 km	1.018	0.370
	Mileage per year more than 15,000 km	−1.018	0.370
Age of current car	Car age < 5 years	−1.282	0.025
	Car age > 5 years	1.282	0.025
Life course event	Separation	2.535	0.186
	Baby birth	−1.093	0.638
	Child leave	0.790	0.724
	Losing job	0.647	0.582
	Retirement	2.530	0.078
	Living together with partner who has a car	0.693	0.894
	Living together with partner without a car	−0.693	0.894
	Living together with partner who has a job	−0.429	0.931
	Living together with partner without a job	0.429	0.931
	New job with commute distance of 5 km	0.578	0.710
	New job with commute distance of 15 km	−0.594	0.697
	New job with commute distance of 45 km	0.252	0.842
	New job with commute distance of 75 km	−0.981	0.563
	New job with PT frequency every 15 min	−0.239	0.821
	New job with PT frequency every 30 min	0.031	0.972
	New job with PT frequency every 60 min	0.208	
	Income change	−2.678	0.748
Maintenance costs	0 euro/month	1.226	0.072
	10 euro/month	−0.570	0.447
	20 euro/month	−0.656	
Operating costs	0.2 euro/km	0.439	0.077
	0.3 euro/km	−0.439	0.077
Hourly rate of car sharing	4 euro/hour	−0.409	0.447
	6 euro/hour	0.409	0.447
Time to pick up point	5 min	0.279	0.656
	10 min	0.495	0.463
	15 min	−0.774	
Availability	60%	−1.189	0.093
	80%	0.224	0.723
	100%	0.965	
Sell current car			
Maintenance costs of current car	Less than 1000 euro per year	−0.820	0.028

Table A1. *Cont.*

Attributes	Description	Coef.	*p*
	More than 1000 euro per year	0.820	0.028
Mileage per year	Less than 15,000 km	0.951	0.039
	Mileage per year more than 15,000 km	−0.951	0.039
Age of current car	Car age < 5 years	−1.688	0.003
	Car age > 5 years	1.688	0.003
Life course event	Separation	1.297	0.305
	Baby birth	0.232	0.872
	Child leave	0.758	0.404
	Losing job	0.118	0.905
	Retirement	1.639	0.134
	Living together with partner who has a car	0.855	0.670
	Living together with partner without a car	−0.855	0.670
	Living together with partner who has a job	−0.526	0.789
	Living together with partner without a job	0.526	0.789
	New job with commute distance of 5 km	0.215	0.851
	New job with commute distance of 15 km	0.609	0.698
	New job with commute distance of 45 km	−0.209	0.849
	New job with commute distance of 75 km	−0.424	0.703
	New job with PT frequency every 15 min	−0.237	0.806
	New job with PT frequency every 30 min	−0.146	0.839
	New job with PT frequency every 60 min	0.382	
	Income change	−1.582	0.781
Alternative-specific constant	Keep current car and purchase an EV	−2.036	0.010
	Keep current car and purchase a CV	−1.033	0.046
	Keep current car and purchase an electric bike	−1.761	0.002
	Keep current car and join car-sharing scheme	−3.832	0.000
	Sell current car and purchase an EV	−2.796	0.007
	Sell current car and purchase a CV	−2.427	0.001
	Sell current car and purchase an electric bike	−3.300	0.001
	Sell current car and join car-sharing scheme	−6.444	0.001
	Sell current car	−3.368	0.000
Standard deviation of random parameters			
Alternative-specific constant	Keep current car and purchase an EV	0.279	0.774
	Keep current car and purchase a CV	1.376	0.048
	Keep current car and purchase an electric bike	0.994	0.089
	Keep current car and join car-sharing scheme	3.653	0.000
	Sell current car and purchase an EV	0.210	0.883
	Sell current car and purchase a CV	1.111	0.159
	Sell current car and purchase an electric bike	0.912	0.125
	Sell current car and join car-sharing scheme	0.715	0.181
	Sell current car	4.852	0.000
Error components for alternatives			
Sigmae01	EV	1.792	0.002
Sigmae02	CV	0.702	0.524
Sigmae03	Car-sharing	0.688	0.089
Sigmae04	Electric bike	0.459	0.109
Sigmae05	Keep current car	0.661	0.217
Sigmae06	Sell current car	1.716	0.000
Log-likelihood	−3332.102		
Adjusted Rho squared		0.388	

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