Household vehicle holding decisions in response to life cycle events

Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 37 (2019) 171–178

Transportation Research Procedia

www.elsevier.com/locate/procedia

21st EURO Working Group on Transportation Meeting, EWGT 2018, 17th – 19th September 2018, Braunschweig, Germany

Household vehicle holding decisions in response to life cycle events

Gaofeng Gu[a]*, Dujuan Yang[b], Tao Feng[a], Harry Timmermans[a,c]

a Urban Planning Group, Eindhoven University of Technology, P.O. Box 513, 5600MB Eindhoven, the Netherlands
b Information System Group, Eindhoven University of Technology, P.O. Box 513, 5600MB Eindhoven, the Netherlands
c NUAA, Department of Air Transportation Management, Jiangjun Avenue, Jiangning District, Nanjing 211106, China

Abstract

People choose a new mobility tool when their mobility needs of change or their current vehicle need replacement. Changes in mobility needs may be triggered by life events. A life event triggers households to reconsider their current vehicle holdings and leads them to change their vehicle holdings if the changing demand makes a changed desirable. Electric cars and car sharing provide new options, which deserve studying in the context of sustainable transport and energy consumption. In the context of re-assessing mobility needs, it is important to better understand the process that leads households to purchase an electric car as a replacement or supplement of their current vehicle, or to join car-sharing. To investigate this decision-making process, a stated choice experiment was designed. This paper reports the results of a mixed logit model, which was estimated to assess the degree of heterogeneity among households in their preferences for vehicle purchase and replacement decisions as a function of life events.

Keywords: Electric cars; Car sharing; Electric bikes; Mixed logit model

1. Introduction

To mitigate pollution and energy consumption, plans to stimulate consumers to replace conventional vehicles (CV) with greener means of transportation, such as electric vehicles (EV), electric bikes and car sharing have been put high on the policy agenda. Yet, the market shares of these emerging transportation modes are still relatively small. Several studies have investigated why people purchase an electric car or join a car sharing organization (e.g., Kim, Rasouli, and Timmermans 2014). In case of electric cars, the higher price, limited battery power and supply of charging stations are major factors making people reluctant to buy an electric car (e.g., Brownstone, Bunch, and Train 1999; Ahn, Jeong, and Kim 2008). Uncertainty in car availability is a major factor for not joining a car-sharing organization (e.g., Kim,

* Corresponding author. Tel.: +31 (0)40 247 2301; fax: +31 (0)40 243 8488.
E-mail address: g.gu@tue.nl

2352-1465
10.1016/j.trpro.2018.12.180

Rasouli, and Timmermans 2017).

The decision to buy a new car or join a car-sharing organization is primarily triggered either by the desire to replace the existing car although the mobility needs did not significantly change or by (anticipated) changes in mobility needs. The latter are often triggered by life course events such as change of job, residential relocation, and changes in household composition (e.g., Verhoeven et al. 2005; Oakil et al. 2014). For example, change of job may involve a longer travel time and/or a location that is less accessible by public transportation. It may lead people to change their mode choice from public transportation to the car. If they do not have a car available, it may lead to the decision to buy one. Vice versa, a new job located close to a major train station may induce household to sell their (second) car and use the train. The birth of the first child often leads women to buy a car because it better serves their changing mobility needs.

Few studies have examined the relationship between life cycle events and the purchase of electric cars, electric bikes or the decision to join a car sharing organization. These mobility options provide newly emerging options for households to satisfy their changing mobility needs. For instance, when households with a limited budget experience increasing mobility needs, rather than purchasing an extra conventional vehicle, they could opt for an electric vehicle, which has lower operating costs. This is particularly true when government is offering substantial tax reductions to stimulate electric cars. Alternatively, they could join a car-sharing program if they only occasionally need a vehicle. Generally, every time an individual or household becomes involved decision whether to purchase an extra or new car due to necessary replacement or to increasing mobility needs, they need to decide buying an electric car, a conventional vehicle, an electric bike or join a car sharing program, or use other transportation modes.

The objective of this study, therefore, is to investigate how life cycle events are related to changes in vehicle possession and mobility tools with special emphasis on electric and shared mobility. Most studies about the relationship between life cycle events and vehicle possession are based on revealed data about people's life trajectories. In this study, we use stated choice data, which has more commonly been applied to understand the demand for electric cars and shared mobility (Costain et al. 2012; Rasouli and Timmermans, 2013, 2016; Johnson and Rose 2013; Hoen and Koetse 2014; Hackbarth and Madlener 2016; Becker et al. 2017). Possible key events related to the life courses of individuals and households are incorporated as context variables in the stated choice experiment.

This article is structured as follows. First, we will discuss the design of the stated choice experiment, followed by a discussion of sample characteristics. Then, the stated choice data will be analyzed using a mixed logit model. The results of the estimation will be discussed in section 3. The paper will be completed with conclusions.

2. Design experiment and data collection

To investigate how life events influence vehicle holdings and mobility tools transactions, a stated choice experiment was designed and implemented using a Web-based questionnaire, which consisted of two main parts. The first part asks respondents to provide personal and household socio-demographic information (e.g., age, gender, household composition) and describe the household vehicles (i.e., car type and mileage per year). The second part of the questionnaire concerns the stated choice experiment. The life cycle events were treated as context variables that affect vehicle holding/mobility tools transaction decisions. Consequently, the design of the experiment involves the selection of life cycle events, and the selection and definition of attributes characterizing the transportation mode options.

2.1. Attributes and attributes levels

Life events are key events that an individual may experience during his/her life. In the literature about the relation between car ownership and life events, change in household composition, change of job, change of income, and residential move has received most attention (e.g., Yamamoto 2008; Oakil et al. 2014). In our study, we selected the following the life events: start of joint household (living together/marriage), separation, baby birth, child(ren) leaving home, change of job, retirement, increase of household income, decrease of household income and relocation. No change served as a base.

In the description of the hypothetical choice contexts, further details about the life events were provided to better allow respondents to immerse in the experiment. When an individual starts living together with a partner, any change in vehicle holdings may depend on whether or not the partner has a job and/or car. Therefore, information about the job and car ownership of the partner was provided. When changing job, vehicle holdings decisions may depend on the commuting distance and the level of service of the public transportation system. Distance to the new job location was varied at 5 km, 15 km, 45 km, 75 km, and 105 km, while the frequency of public transportation to the job location was varied at 15 min, 30 min, and 60 min. The decrease and increase in household income were set at 10% and 20% relative to current household income. Considering the influence of travel distance on car holding decisions, the average weekly travel distance for daily activities was specified as 200 km, 500 km, and 1000 km.

Conventional car, electric car, car sharing, and electric bike were selected as the four transportation mode choice alternatives. Based on the literature (e.g., Shaheen and Cohen 2012; Johnson and Rose 2013; Kim, Rasouli, and Timmermans 2014), a set of attributes and attribute levels was selected for each transportation mode as shown in Table 1. Purchase price, maintenance costs and operating costs were selected for all transportation modes. Three levels were defined to vary the purchase price of electric cars: 15,000 euros, 30,000 euros, and 45,000 euros. The price of an electric car was calculated based on the price of the corresponding conventional car. The net price of an electric vehicle relative to the price of the same conventional vehicle was set at a premium price of +15%, +30%, and +45%. Similarly, two levels were defined for the maintenance costs of the conventional vehicle: 150 euros per month and 250 euros per month. The maintenance costs of the electric vehicle were set to 10% and 20% higher than the maintenance costs of the conventional vehicle. The operating costs of the electric vehicle was set to 0.04 euros per km and 0.06 euros per km, while the operating costs of the conventional vehicle were varied at 0.1 euros per km and 0.15 euros per km. The operating cost of car sharing was set to 0.2 euros per km and 0.3 euros per km according to prices commonly asked by car sharing companies. In addition, several alternative-specific attributes were selected. For electric vehicles, driving range, charging time, travel time to charging station, chance of charging opportunity and free parking policy were included. The normal driving range of electric vehicles in the market is around 275 km. Considering the possible improvement of battery technology in the future, we set 450 km as the upper bound of the driving range. Fast and slow charging was expressed in terms of charging time for every 100 km.

For car sharing, the hourly rate was selected as most car sharing companies charge by the hour. The hourly rate was set to 4 and 6 euros per hour. As to the convenience of car sharing, access time and vehicle availability were selected. Access time, which equals the time to the nearest pick up point, was varied at 5, 10, and 15 minutes. Vehicle availability, which means the chance that a car is available, was varied at 60%, 80% and 100%. For an e-bike, the driving range of a single charge was varied as 40 and 80 km. In addition, respondents were informed whether a dedicated bike lane was available or not for their main daily routes.

2.2. Design of experiment

Considering the number of attributes and attribute levels in the experiment, it is prohibitive to create a full factorial design. To reduce the number of choice sets, a *D*-efficient fractional factorial design consisting of 648 profiles from the $2^{13}\times3^{10}\times32$ full factorial design was created. To ensure that the hypothetical life events presented to respondents with a particular socio-demographic profile, respondents were classified into 24 types according to their age, occupation, and living situation to indicate whether a respondent is single or living with a partner, and has children. Realistic choice profiles were assigned randomly to the corresponding types of respondents. For instance, the event of baby birth was assigned only to respondents who have a partner.

Each respondent was presented 8 choice situations. Respondents were requested to carefully read the hypothetical choice situation, indicate transportation mode they prefer if that choice problem would occur and whether they would keep or sell their current car. Consequently, respondents could choose from 10 options; keep the current car and buy an EV (Keep + EV); keep the current car and buy a CV (Keep + CV); keep the current car and join a car sharing organization (Keep + sharing); keep the current car and buy an E-bike (Keep + E-bike); sell the current car and buy an EV (Sell + EV); sell the current car and buy a CV (Sell + CV); sell the current car and join car sharing (Sell + sharing); sell the current car and buy an E-bike (Sell + E-bike); sell the current car (Sell); and none of these.

2.3. Data collection

The data were collected in the city of Weiz, Austria in October 2017. Before estimating the model, the reliability of the responses was checked. First, 81 respondents who completed the questionnaire within 10 minutes were disregarded because we have doubts on the reliability of their responses. Second, another 7 respondents, who provided stereotyped response patterns, were excluded from the model estimation.

Table 1. Attributes and attributes levels transportation mode options

Attributes	Levels			
	Electric vehicle	**Conventional vehicle**	**E-bike**	**Car sharing**
Purchase price (euros)	15%; 30%; 45% (higher than CV)	15,000; 30,000; 45,000	1,000; 2,000; 3,000	-
Maintenance costs (euros/ month)	10%; 20% (higher than CV)	150; 250	5; 10	0; 10; 20
Operating costs (euros/ km)	0.04; 0.06	0.1; 0.12	-	0.2; 0.3
Hourly rate (euros/hour)	-	-	-	4; 6
Free parking	always; on non-peak hours; no	-	yes; no	-
Driving range (km)	150; 300; 450	-	40; 80	-
Access time (min)	-	-	-	5; 15; 25
Vehicle availability	-	-	-	60%; 80%; 100%
Average travel time to charging station (min)	5; 10 ;15	-	-	-
Fast charging time per 100km (min)	5; 10 ;15	-	-	-
Slow charging time per 100km (hour)	1.5; 3	-	-	-
Chance of charging opportunity	60%; 80%	-	-	-
Bike lane availability	-	-	yes; no	-

Table2 Descriptive statistics

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

After data cleaning, 203 respondents remained for analysis. Consequently, 1,624 choices were used for model estimation. Table 2 presents the frequency distribution of the socio-demographic characteristics. It shows that the number of males and females is almost equally distributed. Regarding their living situation, more than one-third of the respondents lives with their partner and child, while 26.7% lives with their partner without children and about 16% is single. The majority of the respondents has a full-time job, while about 20% has a part time job. Around 43% of the respondents have a gross annual income of between 25,000 and 50,000 euros, while 28% of the sample has a higher income. The remainder has a relatively low income (less than 25,000 euros/year).

3. Model estimation

3.1. Mixed logit model

As electric vehicles are relatively new products and preferences for electric cars may differ by personality and life style, preference heterogeneity in the population should be considered. To capture such heterogeneity, a mixed logit model was used in this study. Because of the sample size, only the random effects of important variables were considered. Price and maintenance costs of electric vehicles were assumed to follow a normal distribution to capture heterogeneity in the population. The utility of alternative *i* for respondent *n* in choice situation *t* can be written as:

$$U_{int} = \alpha_{in} + \boldsymbol{\beta}'^{A}_{i}\mathbf{X}^{A}_{int} + \boldsymbol{\beta}'^{L}_{i}\mathbf{X}^{L}_{nt} + \boldsymbol{\beta}'^{Z}_{i}\mathbf{X}^{Z}_{n} + \varepsilon_{int} \quad (1)$$

where U_{int} is the utility of alternative *i* for individual *n* in choice situation *t*, $\mathbf{X}^{A}_{int}$ is a $(A \times 1)$ vector of the attributes of alternative *i* in choice situation *t*. $\mathbf{X}^{L}_{nt}$ is a $(L \times 1)$ vector of attributes describing the life event context of choice situation *t*. $\mathbf{X}^{Z}_{n}$ is a $(Z \times 1)$ vector of attributes of the socio-demographics and current car of individual *n*. The $(1 \times A)$ vector $\boldsymbol{\beta}'^{A}_{i}$, the $(1 \times L)$ vector $\boldsymbol{\beta}'^{L}_{i}$, and the $(1 \times Z)$ vector $\boldsymbol{\beta}'^{Z}_{i}$ are the parameters for the attributes of alternative *i*, attributes describing the life event context, and attributes of the socio-demographics and current car respectively. α_{in}

is the alternative-specific constant. ε_{int} is a random term that is IID distributed across choice alternatives. For element β_{ikn}^{A} in vector $\boldsymbol{\beta}'^{A}_{i}$, which is the parameter for x_k in the vector $\mathbf{X}_{int}^{A}$, can be specified as:

$$\beta_{ikn}^{A} = \beta_{ik}^{A} + \delta_k \upsilon_{ikn}, \quad \alpha_{in} = \alpha_i + \delta_i \upsilon_{in} \tag{2}$$

where β_{ik}^{A} and α_i are the population means, υ_{ikn} and υ_{in} are random parameters that vary across individuals, with mean zero and standard deviation one. δ_k is the standard deviation of the distribution of β_{ikn}^{A}. δ_i is the standard deviation of the distribution of α_{in}.

3.2. Results

The estimation results of the mixed logit model are listed in Tables 3 and 4. Table 3 shows the parameters related to the life events, socio-demographics, and attributes of current vehicles. Table 4 shows the parameters of the attributes of the new transportation options. Relative to the corresponding multinomial logit model, the goodness-of-fit of the mixed logit model is much higher (log-likelihood increased from in -2367.40 to -1941.44), the Chi square statistic of mixed logit model is 3587.49, the associated p value is 0.29×10^{-6}. The adjusted Rho-squared increased from 0.163 to 0.470 implying that the estimated model has a higher explanatory power.

The signs of most attributes are in line with theoretical expectations. All intercepts are negative, indicating that people are inclined to keep their current cars. Although the electric car is the most popular new transportation mode for people to replace their current vehicle, still the majority of the respondents prefers a conventional car. The standard deviations of each intercept are highly significant, which suggests substantial heterogeneity in people's preferences.

According to the results of the life events, the parameters of purchasing an additional means of transportation triggered by the life event of starting to live together with a partner who has a car are all negative, while the parameters for the alternatives involving replacing or selling their current car are all positive. It indicates that people are more likely to replace or sell their current car than purchasing an additional means of transportation when they are going to live with a partner who has a car. When people start to live together with a partner who has a job, they are more likely to replace or purchase a car than an E-bike or to join car sharing, which suggests people prefer a car to an E-bike and car sharing when their partner has a job. When people separate from their partner, they are inclined to replace their current car rather than sell it or purchase an additional car. Baby birth has a positive effect on purchasing an additional vehicle and a negative effect on purchasing an E-bike and joining a car sharing program. When people have a new job, the probability they purchase another conventional vehicle increases as a function of increasing commuting distance. The probability of purchasing an electric vehicle increases when the commute distance is less than 75 km and decreases when it is more than 75 km. It suggests they are concerned about the driving range. Several studies suggested that retirement most likely leads reduced car ownership (e.g., Oakil et al. 2014). In this study, we found that people are inclined to sell their current car and purchase other types of mobility tools instead of only selling their car.

As for socio-demographics, results show that people who have a job prefer an electric car to other mobility tools and are inclined to purchase an additional vehicle. Commuting distance has a significant influence on the acceptance of E-bike and car sharing. Attributes of the current car also play a role. Respondents are more likely to keep their current car when the maintenance costs of the current car are low. Similarly, people are more likely to purchase an additional vehicle, especially a conventional vehicle, with increasing annual mileage of the current vehicle.

Results also indicate that respondents' propensity to purchase an electric vehicle declines when it is 30% to 45% more expensive than a conventional vehicle. Results suggest that when people purchase an electric vehicle as an additional vehicle, they are more sensitive to price. If the driving range of the electronic car is shorter than 300 km, people tend not to replace their car with an electric vehicle or to purchase an electronic vehicle as an additional vehicle. A free parking policy has a positive effect on the probability of purchasing an electric vehicle. In contrast, free parking only during non-peak hours has no significant influence on the purchase of electric vehicles. For car sharing, the hourly rate has a negative effect on the probability of choosing car sharing. Compared with people who chose car sharing as a substitution of their current car, people who chose car sharing as an additional mobility tool are more sensitive to the hourly rate. For E-bike, the utility of choosing e-bike as a substitute is monotonically decreasing with an increasing price of the e-bike.

Table 3 Estimation results

	Keep + EV		Keep + CV		Keep + E-bike		Keep + sharing		Sell + EV		Sell + CV		Sell + E-bike		Sell + sharing		Sell	
	Coef.	P	Coef.	P	Coef.	P	Coef.	P	Coef.	P	Coef.	P	Coef.	P	Coef.	P	Coef.	P
Constant	-8.553	0.00	-3.308	0.00	-4.289	0.00	-5.658	0.00	-4.754	0.00	-5.534	0.00	-7.349	0.00	-8.195	0.00	-6.100	0.00
Maintenance costs per year less than 1000 €	-0.143	0.67	0.508	0.05	0.384	0.10	0.425	0.29	-0.064	0.80	-0.418	0.15	-0.118	0.72	-0.066	0.87	-0.624	0.08
Maintenance costs per year more than 1000 €	0.143	0.67	-0.508	0.05	-0.384	0.10	-0.425	0.29	0.064	0.80	0.418	0.15	0.118	0.72	0.066	0.87	0.624	0.08
Mileage per year less than 15000 km	0.264	0.53	-0.340	0.19	0.043	0.86	-0.78	0.07	0.689	0.01	0.316	0.28	0.608	0.11	0.816	0.12	0.363	0.28
Mileage per year more than 15000 km	-0.264	0.53	0.340	0.19	-0.043	0.86	0.78	0.07	-0.689	0.01	-0.316	0.28	-0.608	0.11	-0.816	0.12	-0.363	0.28
Vehicle age < 5 years	-0.243	0.57	-0.293	0.29	-0.405	0.13	0.038	0.91	-0.613	0.03	-0.163	0.62	-0.725	0.07	0.199	0.68	0.052	0.88
Vehicle age > 5 years	0.243	0.57	0.293	0.29	0.405	0.13	-0.038	0.91	0.613	0.03	0.163	0.62	0.725	0.07	-0.199	0.68	-0.052	0.88
Separation	-0.891	0.60	-0.157	0.85	0.404	0.66	-1.099	0.46	-1.084	0.28	2.848	0.00	3.093	0.00	3.104	0.02	-5.205	0.06
Baby birth	1.333	0.29	1.805	0.01	0.048	0.96	-0.589	0.67	-1.020	0.39	2.388	0.02	-2.822	0.49	-0.843	0.83	1.682	0.20
Child leave	-0.824	0.71	-0.094	0.90	0.017	0.99	1.995	0.12	1.005	0.26	0.546	0.66	1.536	0.33	-0.801	0.84	1.501	0.18
Loosing job	-1.099	0.40	-1.875	0.01	-0.273	0.77	0.277	0.73	-1.793	0.05	-1.194	0.40	-2.238	0.58	0.975	0.49	3.098	0.00
Retirement	-0.022	0.99	-1.068	0.10	Jan 89	0.01	1.406	0.16	2.961	0.00	1.635	0.08	3.462	0.00	2.572	0.03	0.177	0.89
Living together with partner who has a car	-1.033	0.26	-0.154	0.77	-0.138	0. 85	-0.787	0.33	0.521	0.36	0.178	0.81	1.436	0.25	0.581	0.56	2.191	0.01
Living together with partner without a car	1.033	0.26	0.154	0.77	0.138	0.85	0.787	0.33	-0.521	0.36	-0.178	0.81	-1.436	0.25	-0.581	0.56	-2.191	0.01
Living together with partner who has a job	-0.075	0.93	0.262	0.62	1.565	0.04	0.833	0.29	0.756	0.18	0.982	0.19	-1.044	0.43	-2.042	0.06	-0.038	0.96
Living together with partner without a job	0.075	0.93	-0.262	0.62	-1.565	0.04	-0.833	0.29	-0.756	0.18	-0.982	0.19	1.044	0.43	2.042	0.06	0.038	0.96
New job with commute distance of 5 km	0.086	0.88	-1.401	0.00	3.003	0.00	-1.428	0.04	-1.451	0.00	-1.947	0.01	3.248	0.00	-0.717	0.42	0.683	0.20
New job with commute distance of 15 km	0.570	0.21	-0.246	0.44	1.448	0.00	0.671	0.15	-0.111	0.76	-0.528	0.33	1.479	0.02	0.615	0.43	0.327	0.47
New job with commute distance of 45 km	0.418	0.39	0.124	0.69	-1.57	0.03	0.504	0.32	0.567	0.17	0.444	0.36	-2.632	0.08	0.943	0.24	0.276	0.58
New job with commute distance of 75 km	-0.252	0.66	0.914	0.00	-0.914	0.13	0.603	0.21	0.533	0.09	1.045	0.02	-1.655	0.25	-0.195	0.83	-0.149	0.77
New job with commute distance of 105 km	-0.822		0.609		-1.968		-0.351		0.462		0.986		-0.441		-0.645		-1.137	
New job with PT frequency every 15 mins	0.672	0.09	-0.353	0.12	-0.090	0.73	-0.345	0.35	-0.933	0.00	-1.097	0.01	-0.241	0.58	0.416	0.49	0.382	0.31
New job with PT frequency every 30 mins	-0.938	0.02	-0.075	0.73	0.147	0.58	0.059	0.87	0.153	0.52	0.099	0.78	0.011	0.98	0.472	0.45	0.762	0.03
New job with PT frequency every 60 mins	0.265		0.428		-0.057		0.286		0.781		0.998		0.229		-0.888		-1.145	
Income increase 20%	2.066	0.00	0.385	0.42	0.323	0.55	0.898	0.30	0.855	0.08	2.427	0.00	0.732	0.52	-0.373	0.75	-0.062	0.93
Income increase 10%	-2.066	0.00	-0.385	0.42	-0.323	0.55	-0.898	0.30	-0.855	0.08	-2.427	0.00	-0.732	0.52	0.373	0.75	0.062	0.93
Income decrease 20%	0.135	0.86	-1.07	0.01	-0.028	0.96	0.584	0.41	-0.017	0.97	0.598	0.33	02. Apr	0.01	1.176	0.21	0.718	0.30
Income decrease 10%	-0.135	0.86	01. Jul	0.01	0.028	0.96	-0.584	0.41	0.017	0.97	-0.598	0.33	-2.4	0.01	-1.176	0.21	-0.718	0.30
Relocation travel distance 200 km	1.137	0.14	-0.605	0.21	0.311	0.59	-0.396	0.63	-1.139	0.10	-2.29	0.03	-0.304	0.80	0.549	0.62	1.424	0.04
Relocation travel distance 500 km	-1.240	0.24	0.440	0.35	-0.783	0.26	0.911	0.20	0.467	0.42	-0.030	0.97	0.859	0.48	2.148	0.12	-0.945	0.42
Relocation travel distance 1000 km	0.104		0.165		0.472		-0.515		0.673		2.320		-0.555		-2.696		-0.479	
Fulltime job	1.962	0.00	0.267	0.32	-0.085	0.73	-0.436	0.23	0.68	0.03	-0.189	0.54	0.518	0.18	-0.828	0.13	0.178	0.59
Parttime job	-1.962	0.00	-0.267	0.32	0.085	0.73	0.436	0.23	-0.68	0.03	0.189	0.54	-0.518	0.18	0.828	0.13	-0.178	0.59
Commuting distance shorter than 15 km	-0.073	0.83	0.080	0.76	0.386	0.09	0.515	0.15	-0.818	0.00	-0.024	0.94	-0.303	0.37	-0.473	0.31	0.142	0.67
Commuting distance longer than 15 km	0.073	0.83	-0.080	0.76	-0.386	0.09	-0.515	0.15	0.818	0.00	0.024	0.94	0.303	0.37	0.473	0.31	-0.142	0.67
SD of constant	4.367	0.00	2.807	0.00	2.013	0.00	3.441	0.00	2.754	0.00	2.658	0.00	Feb 55	0.00	3.809	0.00	3.106	0.00

Table 4 Estimation results

		Keep current car		Sell current car	
	Variables	Coef.	P	Coef.	P
EV	Charging opportunity 60%	0.030	0.88	0.076	0.58
	Charging opportunity 80%	-0.030	0.88	-0.076	0.58
	Fast charging per 100 km 5 min	0.442	0.12	0.081	0.67
	Fast charging per 100 km 10 min	0.369	0.21	0.123	0.56
	Fast charging per 100 km 15 min	-0.811		-0.204	
	Free-parking always	0.236	0.44	0.053	0.79
	Free-parking on peak hours	-0.106	0.70	0.054	0.77
	Free-parking no	-0.130		-0.107	
	Maintenance cost 10% higher than CV	0.189	0.40	0.047	0.75
	Maintenance cost 20% higher than CV	-0.189	0.40	-0.047	0.75
	SD of maintenance cost 10% higher than CV	0.394	0.16	0.360	0.13
	Operation cost 0.04 euro/km	0.043	0.83	0.139	0.30
	Operation cost 0.06 euro/km	-0.043	0.83	-0.139	0.30
	Price 15% higher than CV	0.433	0.37	0.299	0.14
	Price 30% higher than CV	-0.279	0.25	0.277	0.16
	Price 45% higher than CV	-0.154		-0.575	
	SD of price 15% higher than CV	0.230	0.61	0.251	0.31
	SD of price 30% higher than CV	1.211	0.01	0.032	0.91
	Price 15% higher * income low	0.280	0.31	-0.125	0.50
	Price 30% higher * income low	0.263	0.38	-0.281	0.13
	Range 150 km	-0.370	0.21	-0.301	0.13
	Range 300 km	0.313	0.32	0.177	0.38
	Range 450 km	0.057		0.124	
	Slow charge per 100 km 1.5 hours	-0.097	0.67	-0.120	0.41
	Slow charge per 100 km 3 hours	0.097	0.67	0.120	0.41
	Time to charge station 5 min	0.697	0.02	0.135	0.44
	Time to charge station 10 min	-0.387	0.21	0.018	0.73
	Time to charge station 15 min	-0.310		-0.154	
CV	Maintenance cost 150 euro/month	0.174	0.15	0.223	0.23
	Maintenance cost 250 euro/month	-0.174	0.15	-0.223	0.23
	Operation cost 0.1 euro/km	0.100	0.42	0.067	0.72
	Operation cost 0.12 euro/km	-0.100	0.42	-0.067	0.72
	Price 15000 euro	0.105	0.56	-0.030	0.92
	Price 30000 euro	-0.011	0.95	0.276	0.33
	Price 45000 euro	-0.094		-0.246	
E-bike	Free parking yes	0.149	0.33	0.130	0.62
	Free parking no	-0.149	0.33	-0.130	0.62
	Bike lane yes	0.108	0.47	0.145	0.54
	Bike lane no	-0.108	0.47	-0.145	0.54
	Maintenance cost 5 euro/month	-0.142	0.36	0.188	0.46
	Maintenance cost 10 euro/month	0.142	0.36	-0.188	0.46
	Price 1000 euro	0.149	0.49	0.084	0.81
	Price 2000 euro	0.321	0.11	0.220	0.50
	Price 3000 euro	-0.470		-0.304	
	Range 80 km	0.119	0.43	0.081	0.74
	Range 40 km	-0.119	0.43	-0.081	0.74
Car sharing	Maintenance cost free	0.460	0.12	0.263	0.56
	Maintenance cost 10 euro/month	-0.041	0.26	-0.038	0.59
	Maintenance cost 20 euro/month	-0.419		-0.226	
	Operation cost 0.2 euro/km	0.171	0.40	0.293	0.35
	Operation cost 0.3 euro/km	-0.171	0.40	-0.293	0.35
	Hourly rates 4 euro/hour	0.063	0.76	0.363	0.27
	Hourly rates 6 euro/hour	-0.063	0.76	-0.363	0.27
	Time to pick up point 5 min	-0.072	0.79	-0.219	0.63
	Time to pick up point 10 min	0.133	0.64	0.092	0.85
	Time to pick up point 15 min	-0.061		0.127	
	Availability 100%	0.286	0.31	0.048	0.92
	Availability 80%	0.024	0.93	-0.153	0.75
	Availability 60%	-0.310		0.106	

4. Conclusions

The objective of this study is to enhance our understanding of how life events influence household vehicle transactions and the acceptance of electric mobility tools and car sharing. A stated choice experiments in which respondents were shown a particular life event and asked if and how they would change their vehicle holdings was administered to collect the relevant data. A mixed logit model was estimated to investigate the effects of attributes of mobility tools, life events, socio-demographics and the characteristics of the current car on transaction probabilities. Results shows that life events have a significant but varied effect on the choice of new mobility options. Overall, based on the results of this study, consumer interest in buying electric vehicles or joining car sharing is relatively low. There is, however, evidence of substantial heterogeneity between individuals. Future studies, therefore, could take into account the influence of people's attitudes in the specification of the choice model. In addition, the potential substitution between alternatives should be treated properly by introducing error components in the model. We plan to address these issues in our future work.

Acknowledgements

This study was supported by research project DESENT, funded under ERANET Co-fund Smart Cities and Communities joint research program (ENSCC), JPI Urban Europe.

References

Ahn, Jiwoon, Gicheol Jeong, and Yeonbae Kim. 2008. "A Forecast of Household Ownership and Use of Alternative Fuel Vehicles: A Multiple Discrete-Continuous Choice Approach." *Energy Economics* 30 (5): 2091–2104. doi:10.1016/j.eneco.2007.10.003.

Becker, Henrik, Allister Loder, Basil Schmid, and Kay W. Axhausen. 2017. "Modeling Car-Sharing Membership as a Mobility Tool: A Multivariate Probit Approach with Latent Variables." *Travel Behaviour and Society* 8: 26–36. doi:10.1016/j.tbs.2017.04.006.

Brownstone, David, David S. Bunch, and Kenneth Train. 1999. "Joint Mixed Logit Models of Stated and Revealed Preferences for Alternative-Fuel Vehicles." *Transportation Research* Part B (34): 1–36.

Costain, Cindy, Carolyn Ardron, and Khandker Nurul Habib. 2012. "Synopsis of Users' Behaviour of a Carsharing Program: A Case Study in Toronto." *Transportation Research Part A: Policy and Practice* 46 (3). Elsevier Ltd: 421–34. doi:10.1016/j.tra.2011.11.005.

Hackbarth, André, and Reinhard Madlener. 2016. "Willingness-to-Pay for Alternative Fuel Vehicle Characteristics: A Stated Choice Study for Germany." *Transportation Research Part A: Policy and Practice* 85: 89–111. doi:10.1016/j.tra.2015.12.005.

Hoen, Anco, and Mark J. Koetse. 2014. "A Choice Experiment on Alternative Fuel Vehicle Preferences of Private Car Owners in the Netherlands." *Transportation Research Part A: Policy and Practice* 61: 199–215. doi:10.1016/j.tra.2014.01.008.

Johnson, Marilyn, and Geoffrey Rose. 2013. "Electric Bikes – Cycling in the New World City : An Investigation of Australian Electric Bicycle Owners and the Decision Making Process for Purchase." *Australasian Transport Research Forum 2013 Proceedings*, no. October: 1–10.

Kim, Jinhee, Soora Rasouli, and Harry Timmermans. 2014. "Expanding Scope of Hybrid Choice Models Allowing for Mixture of Social Influences and Latent Attitudes: Application to Intended Purchase of Electric Cars." *Transportation Research Part A: Policy and Practice* 69: 71–85. doi:10.1016/j.tra.2014.08.016.

Kim, Jinhee, Soora Rasouli, and Harry J.P. Timmermans. 2017. "The Effects of Activity-Travel Context and Individual Attitudes on Car-Sharing Decisions under Travel Time Uncertainty: A Hybrid Choice Modeling Approach." *Transportation Research Part D*: 189–202.

Oakil, Abu Toasin Md, Dick Ettema, Theo Arentze, and Harry.J.P. Timmermans. 2014. "Changing Household Car Ownership Level and Life Cycle Events: An Action in Anticipation or an Action on Occurrence." *Transportation* 41 (4): 889–904.

Rasouli, Soora and Harry J.P. Timmermans. 2013. "Incorporating Mechanisms of Social Adoption in the Design and Analysis of Stated Choice Experiments: Illustration and Application to the Choice of Electric Cars." *Transportation Research Record* 2344: 10-19.

Rasouli, Soora and Harry J.P. Timmermans. 2016. "Influence of Social Networks on Latent Choice of Electric Cars." *Networks and Spatial Economics* 16(1): 99-130.

Shaheen, Susan A., and Adam P. Cohen. 2012. "Carsharing and Personal Vehicle Services: Worldwide Market Developments and Emerging Trends." *International Journal of Sustainable Transportation* 7 (1): 5–34. doi:10.1080/15568318.2012.660103.

Verhoeven, Marloes, Theo Arentze, Harry J.P Timmermans, and Peter van der Waerden. 2005. "Modeling the Impact of Key Events on Long-Term Transport Mode Choice Decisions: Decision Network Approach Using Event History Data." *Transportation Research Record:* 1926: 106–14.

Yamamoto, Toshiyuki. 2008. "The Impact of Life-Course Events on Vehicle Ownership Dynamics – The Cases of France and Japan." *International Association of Traffic and Safety Sciences* 32 (2). International Association of Traffic and Safety Sciences: 34–43.