Stated preference experiment on the use of one-way off-street Electric Car-Sharing services

Second report: stated preference experiment on the use of one-way off-street Electric Car-Sharing services

Dr. Riccardo Curtale and Dr. Feixiong Liao

01.10.2020

Urban Planning and Transportation group

Department of the Built Environment

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Highlights

- We investigated the user preferences for the electric-car sharing services (ECS) and three user-based strategies for mediating the demand and supply of shared cars.
- It is found that younger generations, males, people with low car-ownership, and train users for long trips are more interested in ECS.
- People interested in ECS are willing to collaborate in user-based relocation strategies that compensate users for taking extra efforts in their trips.
- Distant pick-up is the most favorite relocation strategy, followed by distant drop-off and sharing the vehicle.
- People with work, study, or business-related trips are more willing to share the vehicle.
- For long-distance trips, the estimated incentive for every additional walking minute due to distant pick-up or distant drop-off is around 0.33 €.
- Car users are less willing to use ECS. The introduction of ECS is not a sufficient condition for transport mode shift.
- People interested in ECS do not present significant differences in preferences for sanitation before use or cleaning material inside the car. ECS may be considered as a tool to unburden the density of travelers on public transport during the times of COVID-19.

Table of Contents

1. Introduction

This report presents the second-round analysis results for Task A2007 in the OSCAR project, funded by the European Institute of Innovation & Technology (EIT) Urban Mobility. The research activities take place at the Urban Planning and Transportation Group, Eindhoven University of Technology (TU/e for short hereafter). The second-round analysis aims to investigate through a stated preference (SP hereafter) experiment people's willingness to switch from the current means of transport to one-way off-street Electric Car-Sharing services (ECS hereafter). The specific objective of this study is four-fold: (1) investigate people's willingness to switch mean of transport in favor of ECS; (2) identify socio-demographic characteristics and mobility preferences of people interested in ECS; (3) test people's willingness to collaborate in user-based relocation strategies; (4) measure the incentive that users are willing to accept to pick-up or drop-off cars in locations that are less convenient to them but more desirable to the service operator.

1.1. The relocation problem of one-way off-street ECS

Different from free-floating carsharing, in the one-way off-street ECS the users need to pick-up and drop-off the shared electric cars (e-cars hereafter) at designated off-street parking areas, not necessarily the same places. For the use of ECS, individual needs and system efficiency may not be met simultaneously, generating a problem of supply-demand mismatch of shared cars at certain stations. To solve this problem, relocation strategies are needed. Two types of relocation strategies are identified for human-driven shared cars, namely, operator-based and user-based. From a supplier perspective, user-based relocation strategies are preferred to operator-based for cost-efficiency. In user-based relocations, customers collaborate with the ECS by picking-up or dropping-off the shared car, respectively, in under-demanded or under-supplied stations. However, starting or finishing a trip in locations different from their plan is less desirable by customers. Therefore, to motivate users' collaboration, companies should compensate them with incentives. Thus, there is a need for ECS operators to identify the best incentive strategies that fulfill the objectives of the ECS operators and users.

1.2. Structure of the report

The structure of the report is as follows. Chapter 2 illustrates the SP experiment, the survey design, and data collection procedure. Chapter 3 entails the characteristics of the sample, descriptive statistics of their behavior, and the results of the experiment. Chapter 4 provides managerial implications and Chapter 5 summaries the findings.

2. Stated preference experiment, questionnaire, and data collection

To investigate respondents' willingness to switch transport means, we opted for an online questionnaire, designed by the Urban Planning and Transportation Group of TU/e.

2.1. The questionnaire

Participants in the survey received a questionnaire composed of three parts. The first part included socio-demographic and transport-related questions. The second part included statements regarding the acceptance of the ECS (the results were summarized in the first report). The third part included a SP experiment simulating hypothetical trip scenarios. In the experiment, every respondent faced eight choice tasks, each of which include their current means of transport, the standard ECS, the ECS with an alternative distant pick-up, the ECS with an alternative distant drop-off, the ECS with shared ride with another unknown customer. A schematic explanation of the ECS alternatives is depicted in Figure 1.

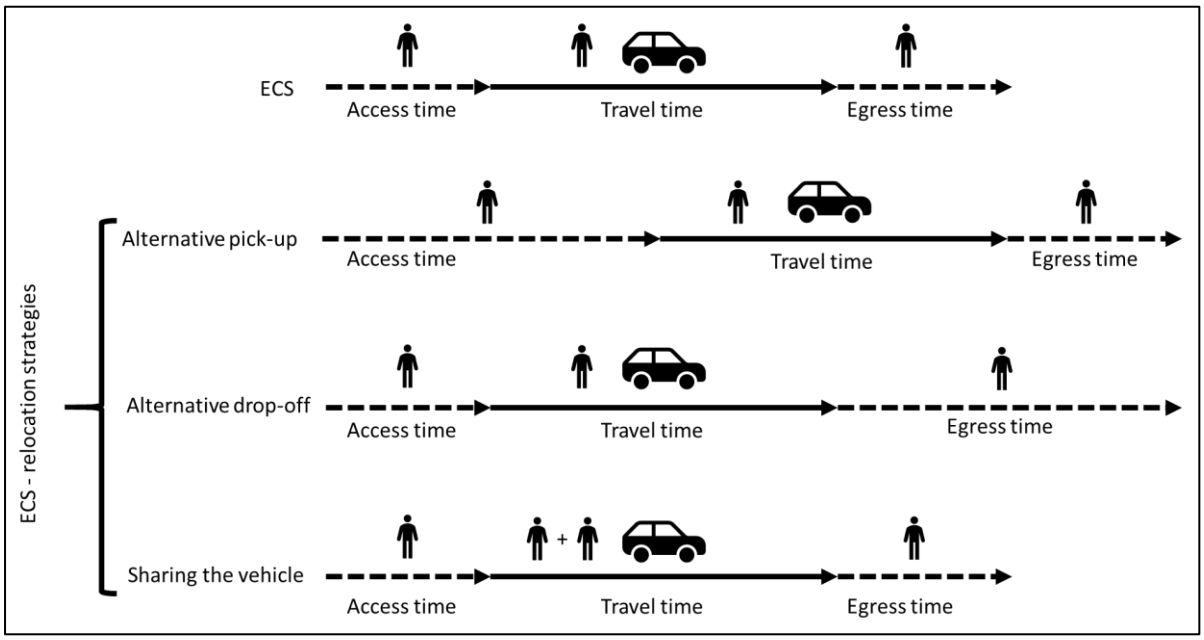
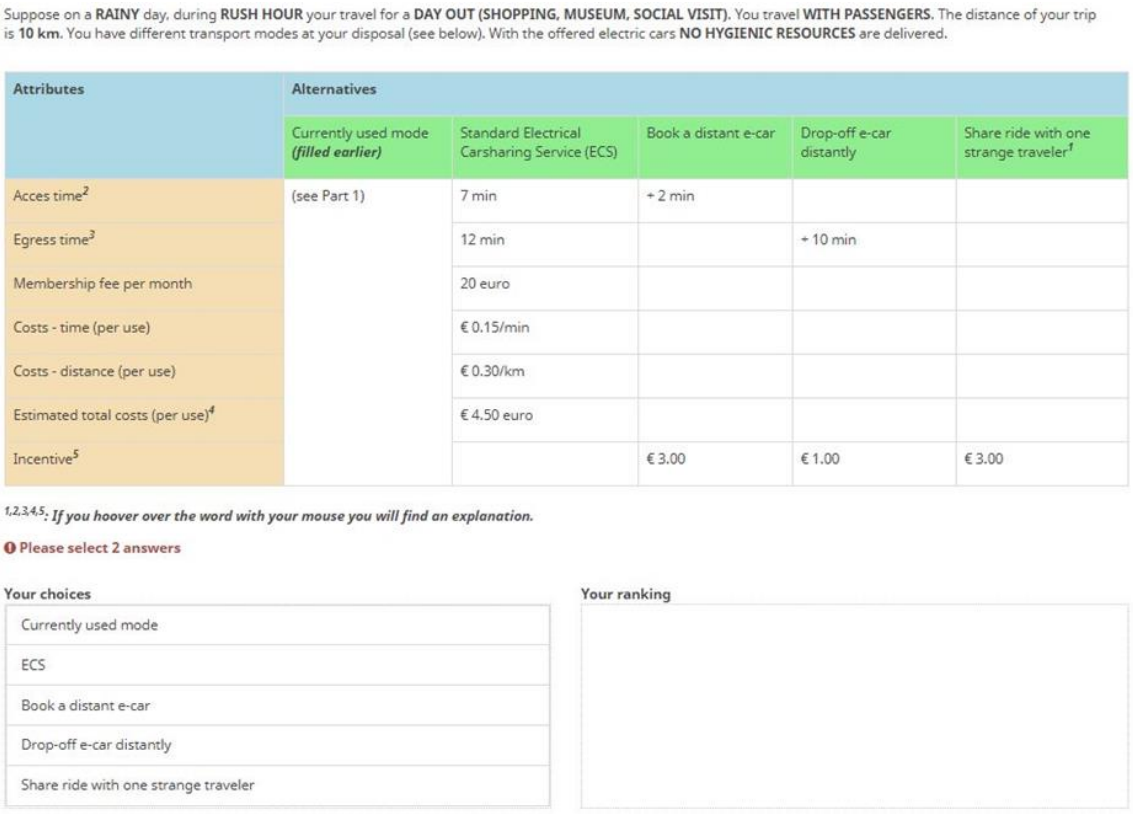


Figure 1 - Alternatives of ECS and user-based relocation strategies

The eight choice tasks presented different configurations of attribute levels and travel contexts to measure people's changes in preference in response to a change in service characteristics. ECS attributes include cost, membership fee, access and egress time, incentive for collaborating with relocation strategies. Travel context regarded weather conditions, time of the day, trip purpose, travel companionship and cleanliness of the car to comply with anti-COVID measures. An example of choice task is depicted in Figure 2. For every choice task, respondents indicated the first two preferences.



Suppose on a **RAINY** day, during **RUSH HOUR** your travel for a **DAY OUT (SHOPPING, MUSEUM, SOCIAL VISIT)**. You travel **WITH PASSENGERS**. The distance of your trip is **10 km**. You have different transport modes at your disposal (see below). With the offered electric cars **NO HYGIENIC RESOURCES** are delivered.

Attributes	Alternatives				
	Currently used mode *(filled earlier)*	Standard Electrical Carsharing Service (ECS)	Book a distant e-car	Drop-off e-car distantly	Share ride with one strange traveler[1]
Acces time[2]	(see Part 1)	7 min	+ 2 min		
Egress time[3]		12 min		+ 10 min	
Membership fee per month		20 euro			
Costs - time (per use)		€ 0.15/min			
Costs - distance (per use)		€ 0.30/km			
Estimated total costs (per use)[4]		€ 4.50 euro			
Incentive[5]			€ 3.00	€ 1.00	€ 3.00

[1,2,3,4,5]: If you hoover over the word with your mouse you will find an explanation.

Please select 2 answers

Your choices

- Currently used mode
- ECS
- Book a distant e-car
- Drop-off e-car distantly
- Share ride with one strange traveler

Your ranking

Figure 2 - Example of choice task

2.2. Data collection

The data collection was conducted between June 22nd and July 9th of 2020. The target population refers to adults living in the Netherlands and owning a driving license. Every respondent received instructions on how to complete the survey and filled a consent form before participating in the survey. The data collection was completed after four waves, each one followed by data analysis of the sample's characteristics to ensure the representativeness of the Dutch population.

3. Results

3.1. Sample characteristics and mobility behavior

The final sample is composed of 739 respondents, who present heterogeneous socio-demographics characteristics (Table 1). Overall, the sample is representative of the Dutch population except that the female and high-educated are slightly over-representative, but the proportions are still acceptable and in line with other studies conducted in the Netherlands. Regarding mobility preferences, most respondents own at least one private car, higher than the Dutch population, but it is acceptable due to the screening procedure. Respondents selected private cars as the most preferred means of transport for short and long trips.

Table 1 - Frequency distribution of socio-demographic and transportation-related characteristics of the sample (n=739)

Variable	Levels	Percentage
Gender	Male	46.4%
	Female	53.6%
Age	<30 years old	21.4%
	30-50 years old	38.6%
	>50 years old	40.1%
Gross monthly income	low (< 2,500 €)	41.8%
	medium (2,501 - 4,500 €)	43.5%
	high (> 4,500 €)	14.7%
Education level	low	12.2%
	medium	36.9%
	high	50.9%
Car ownership	0	10.6%
	1	62.4%
	2 or more	27.0%
Preferred mode of transport for a short trip (around 10 km)	own car	54.7%
	bike	36.0%
	public transport (bus, tram, metro, etc.)	7.4%
	other	1.9%
Preferred mode of transport for a long trip (around 150 km)	own car	85.1%
	train	11.4%
	other	13.5%

3.2. Experiment results

In this section, descriptive statistics of the SP experiment and results of discrete choice modeling of the respondents' choices are reported. Discrete choice modeling is an econometric technique that allows a joint measure of the impact of a change in some characteristics of the ECS on the probability of choosing ECS alternatives and statistically significant differences across respondents' preferences. Section 3.2.1 shows the percentage of people who considered at least one ECS alternative in their choices. Section 3.2.2 presents the descriptive statistics of SP choices depending on socio-demographic and transport-related characteristics. The effects of contextual variables on respondents' preferences are elaborated in Section 3.2.3. Section 3.2.4 shows attributes' effects on respondents' preferences while Section 3.2.5 provides an estimation of the optimal incentive strategy based on the marginal value of people's walking time.

3.2.1. Willingness to try the ECS

From the 739 respondents of the survey, 284 chose at least once one ECS alternative in the experiment, corresponding to 38.4% of the sample. Willingness to try ECS varies depending on socio-demographic variables (Figure 1) and transport-related characteristics (Figure 2).

Regarding socio-demographic variables, males are significantly more willing to try ECS compared to females, people above 50 years old are significantly less willing to try ECS compared to younger respondents, and high-income respondents are significantly more willing to try ECS compared to those with lower income. The other differences, which are not statistically different due to similar preferences or small sample size, are reported in Figure 3.

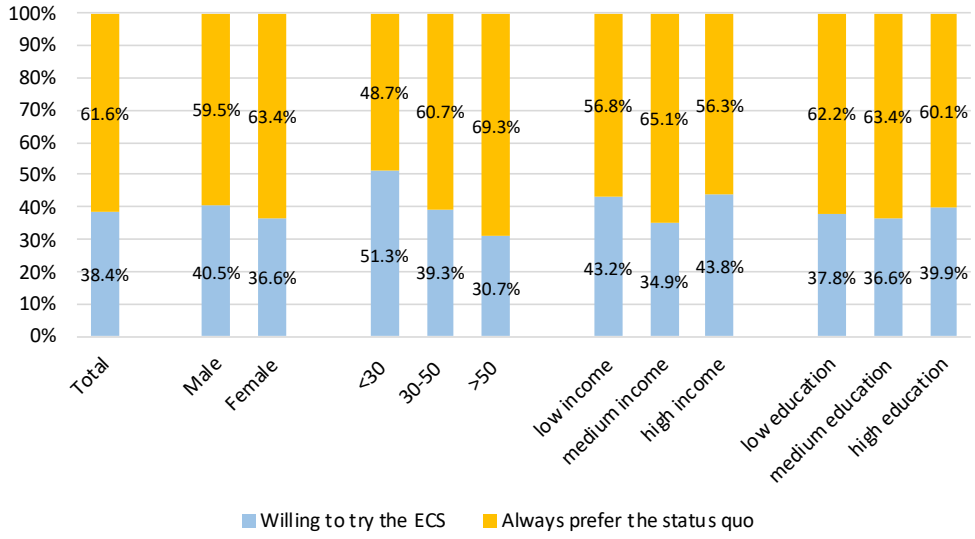


Figure 3 - Percentage of respondents who chose at least once to use an ECS alternative in the proposed experiment. Specific percentages for gender, age, income, and education level are provided.

Regarding transport-related characteristics, respondents owning two or more cars are significantly less willing to try ECS compared to those owning zero or one car, and people who usually travel by train for long distances are significantly more willing to try ECS compared to those who prefer traveling by car. Other differences, which are not statistically significant due to similar preferences or small sample size, are reported in Figure 4.

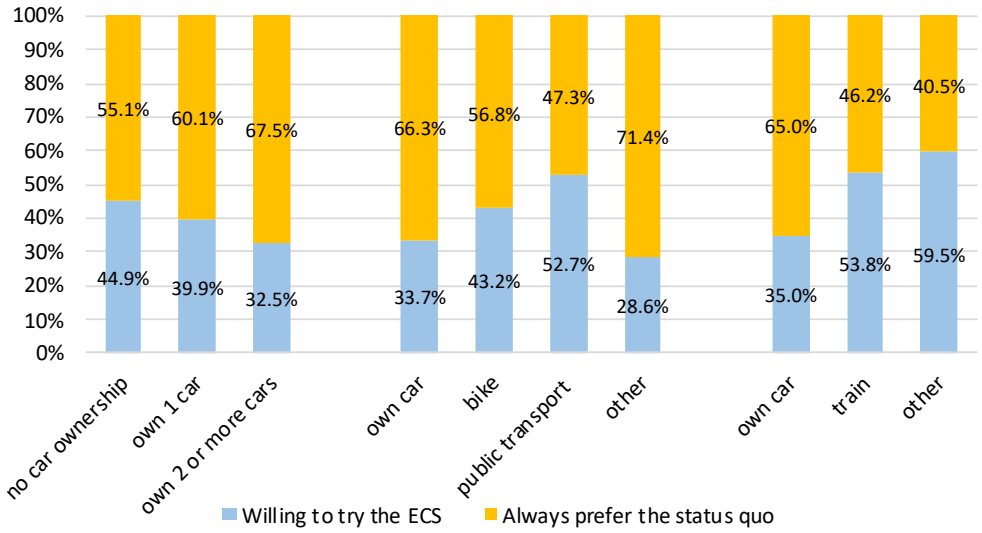


Figure 4 - Percentage of respondents who chose at least once to use the ECS alternative in the proposed experiment. A specific percentage is provided depending on car ownership of the respondents and their current favorite means of transport for a short trip (less than 10 km) or a long trip (more than 100 km).

3.2.2. Preferences for ECS alternatives

Considering all respondents, 5,912 different choices (observations) were analyzed. Of those, 1,307 referred to an ECS alternative, corresponding to 22.1% of the whole sample (Table 2) while the majority (77.9%) preferred the status quo.

Table 2 - SP experiment results. Number of times that the current mean of transport or the ECS have been chosen in the 5'912 scenarios proposed in the experiment.

	Current means of transport	Electric car-sharing service alternatives
Number of times chosen	4,605	1,307
Percentage	77.9%	22.1%

Among the four ECS alternatives, one represents the standard service, while the other three present a variation that requires collaboration from the customers for a user-based relocation strategy. The standard ECS alternative is the most frequently chosen (48.9% of the choices - Table 3), but users are also willing to select alternative ECS. In particular, booking a distant car is the most favorite alternative (27.5%), followed by dropping the car at a distant location (12.6%) and by sharing the vehicle with another customer (10.9%). Overall, it is interesting to note that the sum of the percentages of relocation strategies is greater than that of the standard ECS.

Table 3 - SP experiment results. Preferences for the different types of service proposed by the ECS for the 1'307 cases in which ECS has been chosen over the current mean of transport.

	Standard service	Distant pick-up	Distant drop-off	Share the vehicle
Number of times chosen	639	360	165	143
Percentage	48.9%	27.5%	12.6%	10.9%

Preferences for the different types of ECS are heterogeneous depending on the socio-demographic and transport-related characteristics of the respondents (Figure 5). Males and younger respondents have a higher preference for ECS compared to other categories. A higher number of owned cars reduces the probability of switching to an ECS alternative. Train users for a long trip are more willing to switch to ECS compared to car users. This evidence indicates that ECS might be a stronger potential substitute for their current means of transport for train users compared to car users.

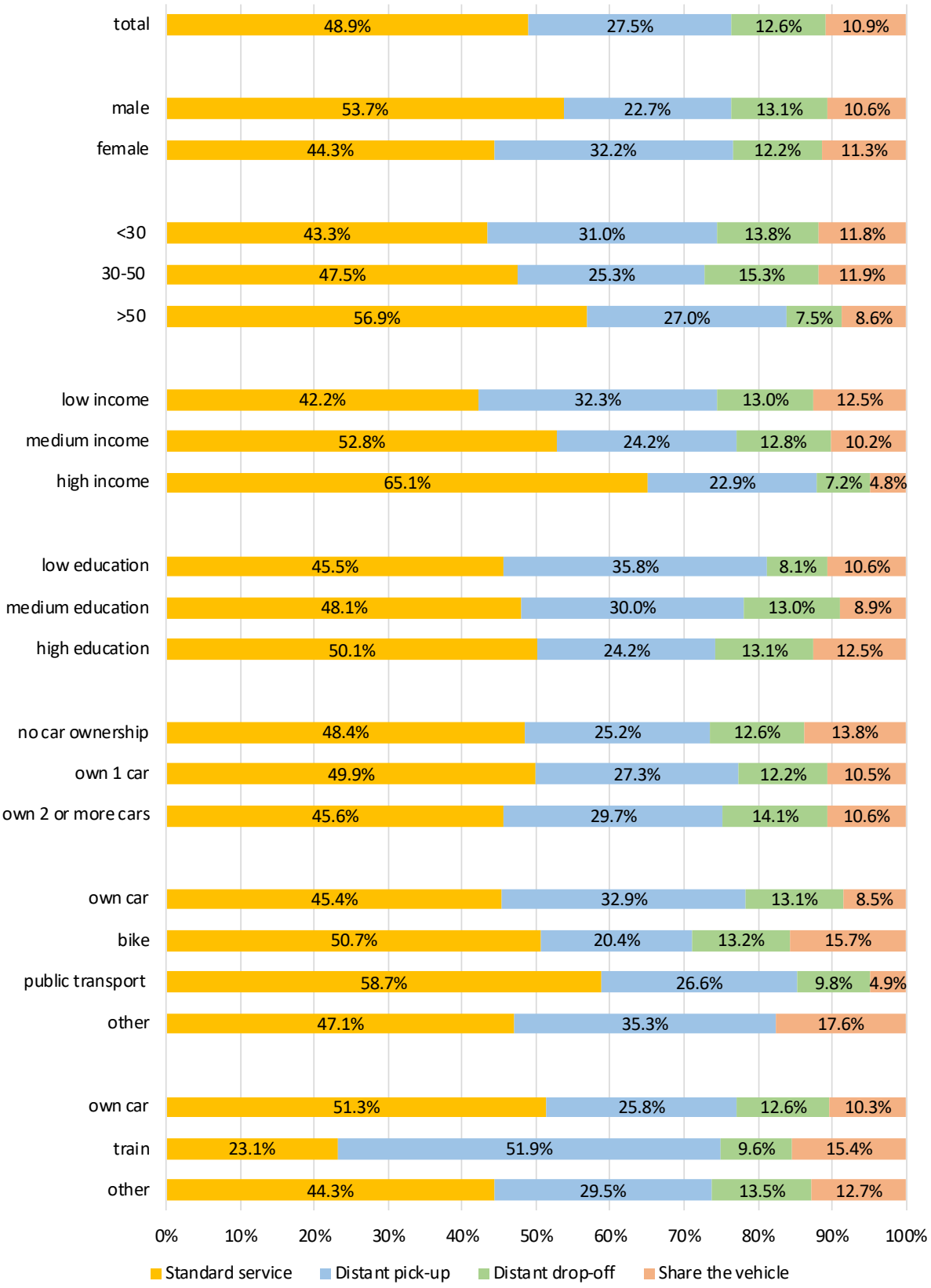


Figure 5 - Percentage of preferences for alternative types of ECS services. Specific percentages are provided depending on gender, age, income level, education level, car ownership, the current favorite mean of transport for a short trip (<10km), and a long trip (>100 km). Results are based on 1'307 choices expressed by the subsample of 284 respondents who chose at least once an ECS alternative in the experiment.

3.2.3. Context effect

As preferences for ECS might change depending on external variables, such as weather conditions, time of the day, trip purposes, travel companionship, and COVID-related cleaning of the car, several scenarios were proposed to respondents. Trip purpose and travel companionship are the only contextual variable presenting significant differences (Figure 6). People traveling for work, study, or business-related purposes are more willing to use the standard ECS or a shared vehicle compared to people traveling for leisure purposes. People traveling with passengers are less willing to drop a distant car or share the vehicle.

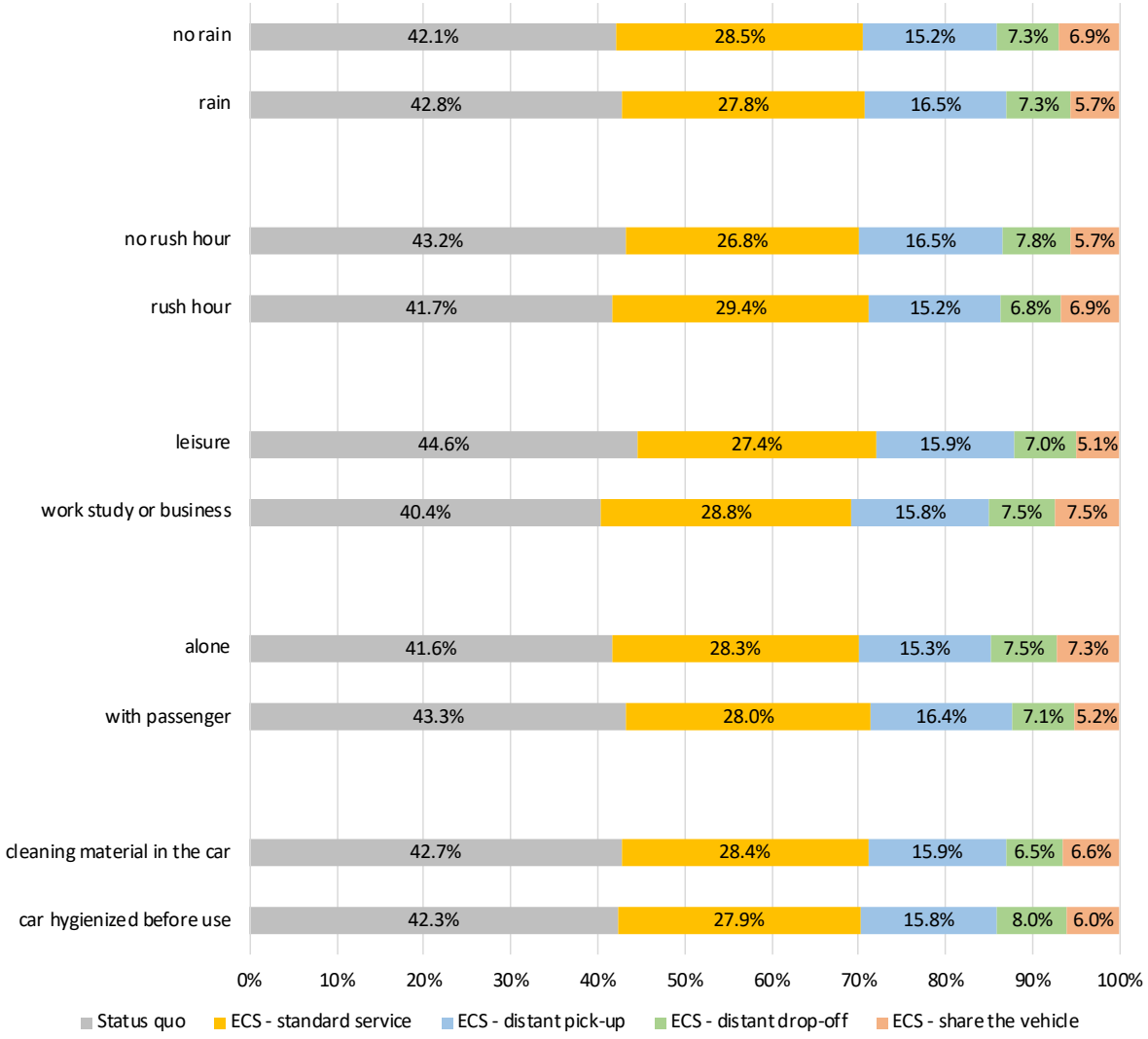


Figure 6 - Percentage of times that alternatives have been selected in the experiment depending on the contextual variables. Results are based on 5'912 choices expressed by 739 respondents.

3.2.4. Attributes effect

To measure users' sensitivity to different characteristics of the ECS, the levels of some attributes of the service were variated in the experiment. Thus, different levels of the membership fee, ride cost, amount of the incentive, and walking time to pick-up or drop-off the car were considered. A discrete choice modeling has been applied to measure the impact of a change in attributes' levels on people's probability of choosing ECS for the proposed scenario. The results of the estimations show that users are sensitive to a change in attribute levels. The increase of membership fee, cost, and walking time to reach the car significantly decreases the probability of choosing an ECS alternative. The increase of the incentive has a positive impact on the probability of choosing the ECS, but it is significant only in the long-distance scenario (Table 4).

Table 4 - Impact of the increase of attributes' levels on the probability of choosing an ECS alternative. The incentive for cooperating is significant in the long-distance scenario only

	negative effect	positive effect
Membership fee	×	
Ride cost	×	
Incentive for cooperating		×
Walking time	×	

A change in attributes' levels of the ECS does not have a homogeneous effect across the population, but it has a different impact on people's choices depending on their characteristics (Table 5). The impact of the membership fee is homogenous across the sample, without socio-demographic or transport-related differences. An increase in the cost of the service has a stronger effect on females, people older than 50 years old, and highly educated people. The demand for these categories can be considered as more elastic to a change in cost of the service. Therefore, a change in the cost of ECS would affect greatly their demand compared to other categories of people. The positive impact of the incentive is higher for people with income lower than 2,500 €/month, for those who use bike as the current means of transport for short trips, and for those who use the train for long trips. Respondents owning more than one car are less sensitive to incentives. Every additional walking minute for picking-up or dropping-down a distant car is perceived more negatively by people older than 50 years old, while it has a weaker effect on train users and people younger than 30 years old.

Table 5 - Impact of attributes' levels change on the probability of choosing an ECS alternative. The main effects of the attributes (listed in the first row) on the choice are those presented in Table 4. "+" indicates the categories who are more sensitive to a change in the level of the respective attribute, compared to the reference level (expressed in the first column), "-" indicates a lower sensitivity.

Variable		membership fee	cost	incentive	walking time
Gender (reference = male)	female		+		
Age (reference = 30-50)	<30				–
	>50		+		+
Income (reference = medium)	low			+	
	high				
Education level (reference = medium)	low				
	high		+		
Current mean of transport for trips shorter than 10 km (reference = car)	bike			+	
	public transport				
Current mean of transport for trips longer than 100 km (reference = car)	train			+	–
Car ownership (reference = 0 cars)	1				
	2 or more			–	

3.2.5. Value of walking time and optimal incentive

A higher incentive increases the probability of choosing alternative services compared to the standard ECS. The more distant a pick-up or a drop-off is, the lower the probability that a user will opt for that ECS alternative. Given the trade-off between incentive and distance, it is important to identify the minimum incentive that users are willing to accept for every additional walking minute caused by a distant pick-up or drop-off of the vehicle. Through discrete choice modeling analysis, it is possible to estimate the optimal incentive, which is obtained by the ratio of the walking time and incentive parameters. The optimal incentive obtained in the experiment is equal to 0.33 €/minute. This means that, as an example, if booking a distant car requires 10 additional walking minutes compared to a closer car, users will be willing to book the alternative car only if the incentive is no less than 3.30 €. Besides, with the incentive being equal, respondents are more willing to book a distant car rather than drop-off the car at a distant location. The results are significant in the long-distance scenario only. However, it is not possible with the current data to provide a specific reason why the incentive is not significant in the short-distance scenario. It might be because people's willingness to collaborate is higher when the marginal increase in travel time is relatively small compared to the total travel time. Therefore, people may accept a compensation for every additional walking time only if the marginal added time represents a low percentage increase of the total travel time. Further research is need on this regard.

4. Managerial and policy implications

The results of the experiment show that there is a potential market for ECS. A considerable percentage of respondents is willing to try the services for their short or long trips. Males, younger generations, people with low car ownership, and train users represent the segment of people more interested in the services (Table 6). As per the contextual influences, ECS are more attractive for work, study, or business-related trips, while relocation strategies are less attractive when have travel companions. Therefore, the use of ECS should be incentivized as an alternative solution to car commuters. A change in the attributes of the service can make the ECS more attractive also for a broader population. In fact, lower costs and access times make the service more desirable and could attract also other segments, such as females, people older than 50 years old, and highly educated people, whose probability of choosing the ECS significantly increases with a lower cost of the services. People interested in the services are willing to collaborate with the service provider for the relocation of the vehicles if adequately compensated. Therefore, ECS companies can rely on users' collaboration for more efficient fleet management, being aware that distant pick-up is the most favorite across alternative services, followed by distant drop-off and sharing the vehicle. Reasonable compensation for every additional walking minute due to distant pick-up or drop-down is estimated at around 0.33 €, with low income, bike users for short trips, and train users for long trips being more sensitive to the incentive.

From a policy-maker point of view, it is important to be aware that people are reluctant about changing their mobility habits, especially for car users. Consequently, wider and faster adoption of ECS might depend on regulations. In fact, ECS seem to be more likely a substitute for public transport users, and to a less extent for private car users. Therefore, the introduction of ECS alone is a necessary but not a sufficient condition for transport mode shift. Some specific policies could enhance a change in mobility habits. As an example, the regulation of traffic-restricted zones in urban areas equipped with cheap ECS vehicles may accelerate the shift from private cars to ECS. In addition, if ECS operators guarantee compliance with hygiene requirements, the introduction of ECS for people's mobility might be also a potential tool to reduce the risk of contagion of COVID-19. In fact, splitting travel demand across several transport modes might reduce density in public transport vehicles. However, the additional cost for operators of ensuring high cleanliness standards in the vehicle should be incentivized by governments, which need to consider it as an investment to reduce risk contagion.

Table 6 - Summary of managerial implications

	Standard service	Distant pick-up	Distant drop-off	Share the vehicle
More willing to try	• Males • Younger than 50 years old • Income higher than 4,500 € • Train users for long trips			
Sensitivity to a change in attributes' levels	• Lower membership fee increases the probability of choosing the ECS • Lower cost increases the probability of choosing the ECS • Lower access time and egress time increase the probability of choosing the ECS • Higher incentive increases the probability of choosing distant pick-up/drop-off and share the vehicle			
Incentive for additional walking minute		0.33 € (in the long-distance experiment only)		
More sensitive to cost	• Females • Older than 50 years old • High education			
More sensitive to incentive		• Low income • Bike users for short trips • Train users for long trips		
Less sensitive to walking time	• Younger than 30 years old • Train users for long trips			

5. Conclusions and plan of the third-round analysis

This report aimed at identifying user preferences for one-way off-street electric car-sharing services (ECS). Analysis results from a representative sample of the Dutch population show that it is possible to identify a segment of people interested in the services and that their willingness to participate in user-based relocation strategies depends on socio-demographic variables, transport-related characteristics, and the amount of the incentives. However, ECS seem to be preferred by people who already use sustainable means of transport, with a lower preference for car users. The interventions of policy-makers seem necessary to expand the user base and guarantee environmental benefits from the introduction of ECS.

Further analysis will be conducted for the final report. The next round analysis will be aimed at (1) investigating the role of other sharing modes, such as electric micro-mobility services; (2) replicating the experiment in different European countries; (3) simulating the impacts that the introduction of ECS might have on urban network congestions; and (4) providing a comprehensive framework of all the analyses.

6. Contacts

Dr. Riccardo Curtale
Postdoctoral researcher
r.curtale@tue.nl

Dr. Feixiong Liao
Assistant professor
f.liao@tue.nl

Urban Planning and Transportation group

Department of the Built Environment

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY