eHUBS - Smart Shared Green Mobility Hubs

Deliverable 4.1

Report of behavioral analysis and choice models for each eHUB city

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EXECUTIVE SUMMARY

This report presents the factors which can explain the propensity for using the eHUBS. We explored a wide array of factors including eHUBS level of service attributes, trip characteristics, socio-demographic and attitudinal variables. Moreover, we aimed to explore the added value of eHUBS compared to unimodal shared mobility services.

The analysis in this report is based on two batches of survey data. The first survey elicits people's general intention regarding using eHUBS (whose general aggregated results have already been delivered). The second survey uses a stated choice experiment to collect people's preference for eHUBS. Stated choice experiment consists of a series of choice sets: each choice set includes several alternatives (such as shared EV and shared e-bike) that are described by a number of attributes, such as travel time, travel cost, access time to shared vehicles in our case. The respondents are asked to make a choice for each set. Therefore, a stated choice experiment records how respondents' choice adapts along with the changes in attributes values and allows investigating the impact of attributes on choices.

We distributed the second[1] survey (using professional panel companies) in Amsterdam and Manchester among adults who have a driving licence. The stated choice experiment was not possible to be done as part of the first survey because of the duration of that survey was already rather long. Therefore, the detailed stated choice experiment was only done in a separate survey afterwards with cities that required more detailed knowledge about the behavior of their citizens regarding the hubs. The valid sample size (used for the analysis in this report) is 880 for Amsterdam and 973 for Manchester. Multiple statistical models were applied in the analysis including discrete choice model and latent class choice model.

The main findings are as follows:

- The choice of eHUB usage is significantly influenced by attributes such as access time, parking time and parking cost. Travel time and cost variables are not always significant in the short trip setting (trips shorter than 10km). Public transport users are more likely to switch to eHUBS compared to car users while private bike users are less likely to switch than car users (Section **2.2.2**).
- Many sociodemographic variables (such as gender, age, education, income), mobility related variables (vehicle ownership and the current mode) and attitudes (pro-shared mobility, perception of the barriers for shared mobility usage) can explain the difference in eHUB preferences (Section **2.2.3**) and the intention to use (Section **2.1**). For example, persons between the age of 18-34 or with a higher education degree have a stronger preference for eHUBS. Moreover, stronger pro-shared mobility attitude and perception of the barriers regarding shared mobility use predict higher intention of using shared mobility.
- Providing two modes in eHUBS can increase the usage of shared mobility in contrast to unimodal shared mobility services. If one mode (shared EV or e-bike) becomes unavailable, the choice probability of using eHUBS has a 1.8-6.2 percentage point decrease (depending on the city and trip purpose). The adaptation pattern when one shared mode becomes unavailable also differs between classes with distinct preference profiles (Section **2.3**).

[1] The details of data collection of first survey can be found in deliverable 3.3.

1 METHODOLOGY

1.1 Survey design

1.1.1 General intention survey design

In the first eHUBS questionnaire survey (QS1), we used an "intention question" to establish people's intention for using eHUBS as a regular (commute) trip alternative. Besides collecting information regarding their socio-demographics and attitudes towards shared mobility in multiple aspects, respondents were asked to state their intention regarding using shared EVs and e-bikes (in combination with public transport or not) for their current regular (commute) trip. Following an ordinal question design, respondents were asked to indicate their intention to use shared vehicles as provided by eHUBS on a 5-point scale ranging from 'I would not use it for any trips of this purpose' (coded 0) to 'I may use it for all trips of this purpose'. Figure 1 shows the layout of the "intention question" as presented to respondents in QS1. More detailed introduction regarding the design of this survey can be found in deliverable D3.3: Report on the aggregate results of the survey.

27. If eHUBS were available in your city, to what extent would you be willing to use the following alternatives for this trip?

	I would not use it for any trips of this purpose	I may use it for a few trips of this purpose	I may use it for many trips of this purpose	I may use it for most trips of this purpose	I may use it for all trips of this purpose
Electric car for the entire trip	○	○	○	○	○
Electric car in combination with public transport	○	○	○	○	○
Electric bike for the entire trip	○	○	○	○	○
Electric bike in combination with public transport	○	○	○	○	○

Figure 1 Simplified SP task for using eHUBs as a regular (commute) trip alternative

1.1.2 Stated preference survey design

The "intention question" in the general intention survey above has several limitations: first, it is framed as an intention instead of a choice between several options, therefore it becomes impossible to study the preference between alternatives (such as between shared EV and e-bike); second, it does not ask the respondent how they intend to adapt their choices when the trip condition changes (such as travel time and cost, access time of the shared vehicles, trip purposes and distance), which does not enable us to explore the impact of these factors on the use of eHUBS. To overcome these limitations and complement the general intention survey, we distributed another survey which mainly consists of a stated choice experiment.

Survey structure

The survey consists of the following sections:

- Current mobility profile: mobility portfolio (e.g. ownership of cars, bikes), travel pattern (frequency of using travel modes such as car, bike, public transport, walking),
- Information of current commute trip / non-commute trip,
- Stated choice experiment for mode choice,

- Socio-demographic information such as gender, age, income, education level and household condition.

Stated choice experiment

We conducted a stated choice experiment to investigate people's mode choice when eHUBs become available. The eHUBS service in our experiment is assumed to be a one-way station-based system: the users can pick up a vehicle from an eHUB station and return it in any other station in the same city. We also assume that eHUBS has perfect level of service: a shared vehicle is always available and there is no parking search time when returning the vehicle. The respondents were given an introduction of the basic characteristics and procedures of using an eHUB before the start of the experiment. The introduction before the commute experiment is as follows:

"Assume there are eHUBs in your city which are mobility hubs providing both shared electric vehicle and shared e-bikes. The following picture illustrates the process of renting and returning an eHUB car/bike:

*The following part of the survey includes **in total 6** tasks. In each task, we will show you a distinct configuration of eHUB: the differences are in terms of characteristics such as its distance from your home and the availability of shared vehicles when you want to use them. For each configuration we will ask you several questions regarding how you intend to adapt **your current commute trip**.*

NOTE: please consider all the characteristics shown when making your choice."

Since people's mode choice may be different depending on their trip purpose, we designed two separate experiments: one for commuting trips and the other for non-commuting trips. Respondents were directed to the commuting experiment if their current commute trip meets the following criteria: 1) not longer than 10 km (longer trips are likely inter-city and unlikely to be covered by the same sharing network); 2) at least 3 times per week (there is little chance of switching between modes if the frequency is only 1 or 2 times a week) and 3) not by walking (these trips are probably quite short and very few would intend to switch towards eHUB). All respondents completed the non-commuting experiment.

For the non-commuting experiments, we further split it into several sub-experiments to include different contexts, since non-commute trips cover a wider range of distances. We designed three sub-experiments, each concerning a trip of around 2 km, 5 km and 10 km. Mode preferences are expected to be different for these three distinct distance ranges: 2 km is the approximate average/median distance for shared micromobility (Reck et al. 2020); 5 km is no longer within "walking distance" for most people; trips over 10km are no longer considered as "short trips" and are unlikely to be covered by an intra-city shared mobility service. A similar division was adopted in a previous mode choice study and people's preferences were found to be distinct for these three distance ranges (Li and Kamargianni 2020). For each of these three sub-experiments, we ask for respondents' preferences for both leisure and shopping trips since shopping trips involve the transport of goods which enables us to explore the preference for cargo-bikes.

We elicit a much richer set of preference information compared to traditional stated choice experiments. Apart from indicating their most preferred mode for the respective (recurring) trip (termed the "choice question"), the respondents have to answer how many days per week (for commute trip)/ how many times out of 10 recurring trips (for non-commute trips) he/she intends to use each alternative (termed the "frequency question"). Furthermore, we also ask how they intend to adapt their allocation of mode use if only one (instead of two) mode is available in the eHUB. Figure 2 shows an example choice task which includes the three different questions.

In order to reduce the cognitive burden on the respondents, we adopted an “adapted” design instead of including all viable transport modes as alternatives in each choice task. In all choice tasks, the respondents choose between three alternatives: their current mode, shared EV in an eHUB and shared e-bike in an eHUB (or shared e-cargo bike in case of a shopping trip). The current mode alternative is thus respondent-specific. The shared EVs and e-bikes are assumed to be always available as noted before.

Every alternative is characterised by a list of attributes: for example, in a mode choice experiment the common attributes include travel time, travel cost, access time to the vehicle/station, etc. The respondents are supposed to tradeoff between different attributes and state their most preferred alternative. In the commuting experiment, we aim to produce realistic choice tasks by fixing the attribute values of the current mode alternative as the real values provided by the respondent and pivoting the attribute values of the other two alternatives around this reference mode. The respondents will provide the following details regarding their regular commuting trip: approximate distance, frequency, most frequently used mode, travel time, congestion, travel cost, access and egress time. For those who use private vehicles, we also ask for their parking search time and parking cost.

In case of the non-commuting experiment, because we cover trips of two purposes and three distances, it is difficult to elicit all detailed information for the six reference trips. Therefore, for each combination of trip distance and purpose (for example a 2 km leisure trip), we only ask for the respondent's most preferred current mode. Instead of being elicited from the respondent and fixed throughout the experiment, the attributes of the current mode are also varied according to the experiment design as the other two eHUBS alternatives .

The attribute values vary in different choice tasks: by analyzing the responses given different combinations of attribute values, we can derive the impact of each attribute on preferences. All attributes involved in the experiment design are varied by three levels. The attribute levels are based on their current value range and/or values in possible future scenarios; in both cases they shall be easily understood by the respondents. Table 1 and Table 2 list the value levels of the attributes which are varied in the experiment.

For each of the four experiments (a commuting experiment and 3 non-commuting sub-experiments for different distances), we constructed an orthogonal design consisting of 27 choice tasks. For the commuting experiment, each respondent is randomly assigned to 6 choice tasks. In the case of the non-commuting experiment, for each of the three sub-experiments of different distances, 2 choice tasks are randomly selected for each respondent; one of them is assumed to be a leisure trip while the other is a shopping trip. Therefore, we also end with 6 (3*2) tasks in total for each respondent.

For a **1-mile leisure trip:**

	Public transport (Bus/tram/train)	eHUBS	
Access (walk to vehicle) and egress (walk to destination) time in total	3 minutes	10 minutes	
Parking search time	0 minutes	None	
		Electric Vehicle	E-bike
Travel time	4 minutes	3 minutes	8 minutes
Congestion		**20%** chance of a **2-minute** delay	
Travel cost	£ 1.5	£ 0.8	£ 1.5

Which option do you prefer for a 1-mile leisure trip?

	Public transport (Bus/tram/train)	Shared electric vehicle	Shared E-bike
Your choice:	○	○	○

a)

How many times would you use each option **if you need to conduct this trip 10 times**? Assume that the shared cars and (cargo)bikes in the eHUB are always available when you need them.

	Public transport (Bus/tram/train)	Shared electric vehicle	Shared E-bike	Total
For every 10 times:	0	0	0	0

b)

If only **one** type of vehicle (instead of two) will be available in the eHUB, how many times would you use each mode **if you need to conduct this trip 10 times**? Please indicate your choice given the following conditions.

Only **Electric vehicle** is available

	Public transport (Bus/tram/train)	Shared electric vehicle	Total
For every 10 times:	0	0	0

Only **E-bike** is available

	Public transport (Bus/tram/train)	Shared E-bike	Total
For every 10 times:	0	0	0

c)

Figure 2. Example of a choice task

Table 1. Attributes for the commuting experiment

Attributes	eHUB	
Access and egress time	2,10,18 min	
	EV	**E-bike**
Travel time	If current mode is car: same as car Otherwise: Reference *80%,100%,120% Reference is calculated based on distance assuming 30km/h	Reference * 80%,100%,120% Reference is calculated based on distance assuming 25km/h
Congestion level	If current mode is car: same as car Otherwise: Chance of delay: 0%, 20%, 40% Possible delay: 25%, 50%, 75% of travel time	
Travel cost	0.15, 0.25, 0.35 €/min	€0.5, 1.5, 2.5 (regardless of distance)

Table 2. Attributes for the non-commute experiment

Attributes	eHUB	
Access and egress time	2km: 2,6,10 min. 5km: 2,10,18min 10km: 2,10,18min	
	EV	**E-bike**
Travel time	2km: 3, 5, 7 min 5km: 7, 10, 13min 10km: 15, 20, 25min	2km: 4, 6, 8min. 5km: 10, 12, 14min 10km: 20, 25, 30min
Travel cost	0.15, 0.25, 0.35 €/min	2km: 0.5, 1, 1.5 euro. 5km: 0.5, 1, 1.5 euro 10km: 1.5, 2, 2.5 euro
Congestion level	Chance of delay: 0%, 20%, 40% Possible delay: 25%, 50%, 75% of travel time	

1.2 Data collection

The first survey was distributed in all six eHUBS pilot cities, namely Amsterdam, Nijmegen/Arnhem, Leuven, Manchester, Dreux and Kempten. It targets the general adult population. The distribution of the socio-demographic variables can be found in the appendix (Table A-1). For more details regarding data collection and the final sample of the first survey, refer to deliverable 3.3.

The target population of our second survey is adults who have driving licence. We exclude people who do not have a driving licence because our study involves shared electric vehicle service and these people are unable to use this service. The survey was implemented on Qualtrics and translated from English into Dutch. We used polling agencies to collect responses in March 2021. We obtained 1003 responses from Amsterdam and 1000 from Manchester as requested. After excluding all responses with less than 5-minute completion time, the final valid sample size used for the analysis in this report is respectively 880 and 973 for Amsterdam and Manchester.

The column of "Total" under the non-commute experiment in Table 9 and Table 12 respectively presents the distribution of all socio-demographic and mobility pattern variables in the

Amsterdam and Manchester sample. Regarding socio-demographic variables, the sample distributions are broadly/approximately similar to the population with respect to age, while slightly underrepresenting males. Highly-educated people are overrepresented, which is probably due to the data collection channel of online survey.

1.3 Data analysis

We used multiple statistical models in our analysis. We will briefly introduce the function of these models:

Logistic regression (section 2.1): this model estimates the impact of factors on the intention of using shared mobility services. This model is used to analyze the result of the "intention question" in the first survey.

Discrete choice model (section 2.1.2): this model estimates the impact of attributes on the probability of an alternative being chosen. This model is used to analyze the result of the "choice question" in the second survey.

Latent class model (section 2.1.3): it can be considered as an extension of the discrete choice model. While a discrete choice model assumes that people's preference for attributes/alternatives are homogeneous, the latent class model assumes that the entire population can be segmented into several classes with different preference profiles. After clustering people based on their preference profiles, we can further examine the distribution of socio-demographic variables and mobility patterns in each class to see how these individual characteristics can explain the difference in preferences. This model is also used to analyze the result of the "choice question" in the second survey.

2 RESULTS

As mentioned earlier we asked three questions for each choice task: the first "choice question" inquires the most preferred alternative; the second "frequency question" asks how many days per week (for commute trip)/ how many times out of 10 recurring trips (for non-commute trips) the respondent intends to use each alternative; while the third question repeats the second question but with only one shared mode (EV or e-(cargo)bike) available instead of two. Section 2.1 presents the analyses done based on the response for the "choice question" while section 2.2 covers the second and third questions.

2.1 Intention for using shared mobility services

We first derived three categorical components from 20 attitudinal statements via Categorical Principal Component Analysis or CATPCA (Table 3 Rotated categorical component (CC) loadings and reliability estimates). Broadly, these three components reflected 1) holding a positive attitude towards, and expressing an interest in trying out, shared mobility options (CC1 Pro-Shared), 2) perceived barriers to the use of shared mobility such as incompatible mobility needs (CC2 Pro-Barriers), and 3) showing concern for environmental aspects (CC2 Pro-environment). To explain peoples' intention to use eHUBS for their commute (regular) trips, four separate logistic regression models were estimated. Each model describes a different mode, namely shared EV, shared EV combined with public transport, shared e-bike and shared e-bike combined with public transport. Socio-demographic variables and the attitudinal components derived above were used as explanatory variables in the models.

For analysis purposes, the 5-point scale was reduced to a binary scale, combining the four options expressing a willingness to use shared options for at least a few regular (commute) trips into one category (coded 1). This step was considered appropriate because the proportion of respondents willing to use shared vehicles was about equal to the proportion of respondents not willing to use shared vehicles (see deliverable D3.3: Report on the aggregate results of the survey). For each shared vehicle type, to compare preferences, 'I would not use it for any trips of this purpose' was chosen as the reference group. Logistic regressions were computed using the backward stepwise method, which starts with a full model including all predictor variables from which non-significant predictors are gradually removed.

Table 4 presents the regression coefficients, significance level, and odds ratios, of the predictor variables that were retained in each model. Variables with a p-value lower than .05 are considered statistically significant at the 95% confidence level. An **odds ratio (OR)** greater than 1 indicates that the variable in question increases the likelihood for a person to belong to the alternative group. Here, this refers to those who indicated 'I may use it [shared mobility option] for at least a few trips of this purpose'. For example, for shared EVs, the OR of a pro-shared mobility attitude is 2.59, which indicates that those who hold a pro-shared mobility attitude are about *two and a half times more likely* to consider using a shared EV for at least a few trips compared to the reference group (i.e., 'I would not use it for any trips of this purpose'). In contrast, an OR lower than 1 indicates that this variable increases the likelihood of belonging to the reference group which is not interested in the use of eHUBS. For instance, for shared EVs, respondents from Belgium appear to be less willing to use EVs from eHUBs as a regular (commute) trip alternative (OR=0.43) or combined with public transport (OR=0.29). Odds ratios can also be interpreted as percentages. For example, having one child in the household increases the odds of considering shared EVs as alternative by +38% (OR = 1.38).

Overall, the four logistic regression models correctly classified between 68-74% of respondents as potential eHUBs users and non-users, respectively. In other words, in most cases, the model predictions were congruent with respondents' stated preferences. Below, the logistic regression results for each shared electric vehicle type are presented in turn.

- ***General findings***. For each shared electric vehicle type, including in combination with public transport, a pro-shared mobility attitude (ORs = 2.31 to 2.59, +131-159%) and the perceived barriers factor (ORs = 1.12 to 1.45, +12-45%) increased the odds of considering the use of shared electric vehicles as an alternative. While the latter might seem counterintuitive, a possible explanation could be that while respondents are generally interested in using shared vehicles as an alternative, this often goes hand in hand with common barriers and misconceptions regarding shared mobility use.

Table 3 Rotated categorical component (CC) loadings and reliability estimates

Attitude statements / Statistics	Measured construct	CC1	CC2	CC3
Cronbach's alpha (α)	Reliability	0.82	0.79	0.80
Explained variance (Eigenvalue / number of items)	Variance	0.18	0.17	0.15
1. I would enjoy trying out and using different electric vehicles from an eHUB.	Trialability (DOI)	0.79		
2. I'd be interested in using eHUBs for commuting trips when they've become available in my city.	Adoption intention for commute (TPB)	0.78		
3. I'd be interested in using eHUBs for non-work trips when they've become available in my city.	Adoption intention for leisure (TPB)	0.77		
4. Shared mobility options provide me with more flexibility in the way I travel.	Relative advantage #1 (DOI)	0.70		
5. I am confident that, if I wanted to, I could use eHUBs without problems.	Complexity #1 (DOI)	0.65		
6. I am often among the first people to experiment with new technologies.	Affinity for technology	0.53		
7. I would rather wait for other people to try eHUBs before I use them.	Delayed adoption intention		0.77	
8. Shared mobility solutions like eHUBs are too complicated for me to use.	Complexity #2 (DOI)		0.73	
9. Shared mobility options cannot fulfil my mobility needs.	Perceived compatibility (DOI)		0.70	
10. I prefer travelling the way I am used to rather than using eHUBs.	Habit		0.69	
11. There is no point in using shared mobility options if you already own a car.	Relative advantage #2 (DOI)		0.68	
12. I do not feel confident to use an electric car.	PBC EV (TPB)		0.54	
13. People should be allowed to use their cars as much as they like, even if it causes damage to the environment.	Car use attitude #3 (TPB)		0.49	
14. Almost everyone around me owns a private car.	Perceived social norm		0.29	
15. For the sake of the environment, everyone should reduce how much they use cars.	Car use attitude #1 (TPB)			0.78
16. I feel a moral obligation to reduce my emissions of greenhouse gases.	Personal norm			0.76
17. Congestion, air pollution and noise from road traffic is a real problem in my city.	Environment attitude #1 (TPB)			0.64
18. People around me find it important to reduce emissions of greenhouse gases.	Perceived subjective norm			0.60
19. People who drive cars that are better for the environment should pay less to use the roads.	Car use attitude #2 (TPB)			0.52
20. I feel confident to ride an electric bicycle.	PBC e-bike (TPB)			0.43

Note: The abbreviation in the bracket after an attitudinal construct denotes the psychological theory it belongs to. DOI: Diffusion of innovation. TPB: Theory of Planned Behavior.

Table 4 Logistic regression coefficients and odds ratios by shared electric vehicle type; acc = accuracy (% classified correctly)

	Shared EV (acc = 71%)			Shared EV + PT (acc = 74%)			Shared e-bike (acc = 68%)			Shared e-bike + PT (acc = 71%)		
Variable	b	p	OR	b	p	OR	b	p	OR	b	p	OR
Constant	-0.32	0.00	0.73	0.09	0.58	1.09	-0.11	0.46	0.90	-0.71	0.00	0.49
Pro shared mobility	0.95	0.00	2.59	0.84	0.00	2.31	0.93	0.00	2.55	0.89	0.00	2.44
Pro perceived barriers	0.22	0.00	1.25	0.38	0.00	1.47	0.11	0.08	1.12	0.21	0.00	1.23
Pro-environment				-0.12	0.06	0.88	0.14	0.02	1.15			
Age = 18 to 24				0.54	0.00	1.72	0.88	0.00	2.41	0.93	0.00	2.54
Age = 25 to 34							0.45	0.00	1.57			
Age = 35 to 44							0.40	0.01	1.49			
Age = 45 to 54				-0.37	0.02	0.69						
Age = 55 to 64							0.43	0.03	1.54			
Country = Belgium	-0.85	0.00	0.43	-1.23	0.00	0.29				-0.64	0.00	0.53
Country = Germany				-0.60	0.00	0.55	-0.59	0.00	0.56	-0.86	0.00	0.42
Country = France	0.78	0.00	2.17							-0.36	0.05	0.70
Country = England	0.32	0.03	1.38				-0.31	0.04	0.74	-0.39	0.02	0.68
Number of adults = 2				-0.51	0.00	0.60	-0.19	0.09	0.83			
Number of children = 0				-0.53	0.00	0.59	-0.28	0.02	0.76			
Number of children = 1	0.33	0.03	1.38							0.46	0.00	1.58
Number of children = 2	0.27	0.06	1.31									
School education							0.33	0.03	1.40	0.34	0.03	1.41
Professional qualification	0.58	0.00	1.78				0.65	0.00	1.92	0.60	0.00	1.82
University degree				-0.43	0.00	0.65						
CO = School/Trainee/Stud.										0.49	0.02	1.64
Income =/< £20,000										0.40	0.01	1.49
Income = £40,000-£59,999				0.42	0.01	1.52						
Income = £60,000-£79,999				0.56	0.00	1.75				0.31	0.08	1.36
Income = £80,000-£99,999	0.49	0.04	1.62	0.70	0.01	2.00						
Number of samples		1730			1685			1707			1688	
Pseudo R^2 (Nagelkerke)		0.28			0.30			0.25			0.27	

- ***Shared EV***. In addition to holding a pro-shared mobility attitude and perceived barriers, living in France (OR = 2.17, +117%) or England (OR = 1.38, +38%), sharing a household with one (OR = 1.38, +38%) or two children (OR = 1.31, +31%), holding a professional qualification (OR = 1.78, +78%), and having an income between £80,000-£99,999 (OR = 1.62, +62%), strongly increases the odds of considering using shared electric cars as a regular (commute) trip alternative.
- ***Shared EV + public transport***. For the combination of shared electric cars and public transport, being between 18 to 24 years old (OR = 1.72, +72%), and having a gross annual income between £40,000 and £99,999 (ORs = 1.52 to 2.00, +52-100%), greatly increases the odds of considering EV + PT as an alternative. On the other hand, holding a pro-environmental attitude (OR = 0.88, -12%), being between 45 to 54 years old (OR = 0.69, -31%), living in Belgium (OR = 0.29, -71%) or Germany (OR = 0.55, -45%), having two adults (OR = 0.60, -40%) or no children in the household (OR = 0.59, -41%), and holding a university degree (OR = 0.65, -35%), decrease the odds.
- ***Shared e-bike***. For shared electric bikes, a pro-environmental attitude (OR = 1.15, +15%), being between 18 to 44 or 55 to 64 years old (ORs = 1.49 to 2.41, +49-141%), and having either school education (OR = 1.40, +40%) or a professional qualification (OR = 1.92, +92%), increases the odds of being willing to use shared e-bikes as a regular (commute) trip alternative for at least a few trips. In contrast, living in Germany (OR = 0.56, -44%) or England (OR = 0.74, -36%), and having two adults (OR = 0.83, -17%) or no children in the household (OR = 0.76, -24%), decrease the odds.
- ***Shared e-bike + public transport***. The willingness to use a combination of shared e-bikes and public transport as a regular (commute) trip alternative is positively predicted by belonging to the youngest age group (i.e., 18 to 24; OR = 2.54, +154%), having one child in the household (OR = 1.58, +58%), having school education (OR = 1.41, +41%) or holding a professional qualification (OR = 1.82, +82%), currently being in school or a trainee/student (OR = 1.64, +64%), and having an income that is either less than £20,000 (OR = 1.49, +49%) or between £60,000 and £79,999 (OR = 1.36, +36%). All country variables, except the Netherlands, decrease the odds of considering shared e-bikes + PT as an alternative (ORs = 0.42 to 0.70, -30 to -58%).

2.2 Mode choice for shared mobility services

2.2.1 Willingness to use eHUBS

Based on the respondents' answers to the choice tasks, we categorised them into four groups:

- Not willing to use eHUB: in case of the "choice question", a respondent falls into this category if he/she did not choose the shared EV or e-bike in any of the choice tasks. In case of the "frequency question", the criterion is not choosing shared EV/e-bike for even once/one day.
- Potential users of shared EV: if the respondent chose shared EV (at least once/one day in case of the "frequency question") in at least one of the choice tasks but did not choose the shared e-bike.
- Potential users of shared e-bike: if the respondent chose shared e-bike (at least once/one day in case of the "frequency question") in at least one of the choice tasks but did not choose the shared EV.
- Potential users of both eHUB modes: if the respondent chose both eHUBS modes at least once.

Table 5 shows the distribution of these four categories in case of both commute and non-commute trips in Amsterdam and Manchester. The group "not willing to use eHUB" is significantly smaller in case of the "frequency question", which implies that we were able to capture more occasional users of eHUBS via this question. The group of "potential users for both modes" is also significantly larger, indicating that the more flexible response format of the "frequency question" also enables us to record more potentially multi-modal respondents. These differences demonstrate the value of the "frequency question" in addition to the traditional choice question. It should be noted that the values of "willingness to use" in Table 5 are subject to our specific experiment setting (the attributes shown to the respondents). These values can be different under different assumptions and should not be directly taken at face value.

Table 5. Willingness to use for eHUBS service

	Amsterdam		Manchester	
	Commute	Non-commute	Commute	Non-commute
Choice question				
Not willing to use eHUB	55.2%	45.0%	60.2%	49.1%
Potential users of shared EV	13.1%	20.1%	12.0%	17.8%
Potential users of shared e-bike	9.7%	14.8%	19.4%	20.2%
Potential users of both eHUB modes	22.0%	20.1%	8.4%	13.0%
Frequency question				
Not willing to use eHUB	43.7%	32.6%	46.9%	31.1%
Potential users of shared EV	11.0%	12.0%	13.5%	17.4%
Potential users of shared e-bike	9.1%	11.6%	21.9%	17.9%
Potential users of both eHUB modes	36.2%	43.9%	17.6%	33.7%

2.2.2 Results of the discrete choice model

In total we estimated four discrete choice models. For each city (Amsterdam and Manchester) we estimated two models separately using the answers of commute and non-commute experiments. Table 6 presents the estimation results of all discrete choice models.

Alternative specific constants (ASCs) reflect people's preference for an alternative beyond the attributes included in the model. The ASC of car (as current mode) is fixed to 0. In our model, the ASCs of different current modes (except for the car) can reflect how likely the users of these modes are going to remain with the current mode compared to car users. For example, the ASC for public transport is negative and statistically significant in all four models, indicating that public transport users are more likely to switch to eHUBS compared to car users. The ASC for bike is positive (although non-significant in two models) meaning that bike users are more likely to continue using their current mode relative to car users. This is an optimistic result because switching from bike to shared electric mobility is increasing the carbon footprint.

All coefficients related to travel cost and travel time variables are negative as expected (except two estimates which are non-significant). However, almost all travel time and cost coefficients in the two Manchester models are statistically significant, while most are non-significant in the two Amsterdam models. Moreover, access time, parking time and cost are all negative and statistically significant in all four models (apart from parking cost in Amsterdam-non-commute model) as well.

Almost all coefficients related to congestion (both frequency and duration) are non-significant. A possible reason is that our experiment setting is short trips under 10km: even the longest congestion duration is not enough to make a difference or there is insufficient variation to achieve statistical significance.

The waiting time for taxi is statistically significant in the Manchester non-commute model and has a positive sign: this seems counter-intuitive, but keep in mind the taxi can only appear as a current mode and its waiting time value is provided by the respondent; therefore, it is fixed for each individual throughout the experiment and can only be interpreted in the same way as a socio-demographic variable. In this specific case it indicates that for people whose current mode is taxi, those with longer waiting times are more likely to remain with their current mode. A possible explanation is that they have a stronger intrinsic preference for taxi and are very satisfied with it despite the longer waiting time.

Table 6 Estimation results for the coefficients in four choice models

		Amsterdam		Manchester	
Coefficient	Meaning of the variable associated	Commute	Non-commute	Commute	Non-commute
ASC_SEB	Alternative specific constant of shared electric bike	**-1.62**	**-2.38**	**-1.38**	**-1.83**
ASC_SEV	Alternative specific constant of shared electric vehicle	**-1.71**	**-2.19**	**-2.07**	**-2.17**
B_SQ_BIKE	Alternative specific constant of current mode (private bike)	*0.287*	0.214	**1.19**	0.416
B_SQ_BS	Alternative specific constant of current mode (bikesharing)	**-1.94**	**-1.71**	6.32	-1.97
B_SQ_CS	Alternative specific constant of current mode (carsharing)	**-1.87**	**-1.82**	/	**-3.31**
B_SQ_EB	Alternative specific constant of current mode (private e-bike)	0.242	**-0.738**	7.6	-1.08
B_SQ_MTC	Alternative specific constant of current mode (motorcycle)	**0.661**	**-0.416**	5.98	3.6
B_SQ_PASS	Alternative specific constant of current mode (car as passenger)	**-1.35**	**-0.994**	**-0.444**	**-0.563**
B_SQ_PT	Alternative specific constant of current mode (public transport)	**-0.871**	**-0.888**	**-1.54**	**-1.17**
B_SQ_TAXI	Alternative specific constant of current mode (taxi)	-0.77	-1.04	/	*-1.96*
B_SQ_WALK	Alternative specific constant of current mode (walking)	/	0.0348	/	**0.376**
B_COST_SEB	Travel cost of shared electric bike in euros/pounds	**-0.293**	**-0.321**	**-0.684**	**-0.629**
B_COST_SEV	Travel cost of shared electric vehicle in euros/pounds	0.00156	-0.0566	**-0.324**	**-0.32**
B_COST_SQ	Travel cost of the current mode in euros/pounds	-0.0197	0.00556	**-0.122**	**-0.154**
B_TIME_SEB	Travel time of shared electric bike in minutes	0.000419	-0.00617	**-0.0552**	**-0.0487**
B_TIME_SEV	Travel time of shared electric vehicle in minutes	-0.0112	-0.0116	**-0.041**	-0.0152
B_TIME_SQ	Travel time of the current mode in minutes	0.00682	**-0.024**	**-0.0494**	**-0.028**
B_ACCESS_EHUB	Access time of eHUB in minutes	**-0.0219**	**-0.0203**	**-0.0715**	**-0.0384**
B_ACCESS_SQ	Access time of current mode in minutes	-0.00829	**-0.0253**	**-0.021**	**-0.0181**
B_PARKC_SQ	Parking cost of current mode in euros/pounds	**-0.0241**	**-0.0488**	*0.0243*	**-0.202**
B_PARKT_SQ	Parking search time of the current mode in minutes	**-0.0431**	*-0.0192*	**-0.241**	**-0.0271**
B_CGFREQ_SEV	Congestion frequency of shared electric vehicle	*0.00713*	-0.011	0.00554	0.00153
B_CGFREQ_SQ	Congestion frequency of the current mode	0.00207	-0.0278	*0.0068*	-0.0242
B_CGTIME_SEV	Congestion time of shared electric vehicle in minutes	-0.00000682	-0.000118	-0.000358	-0.0106
B_CGTIME_SQ	Congestion time of the current mode in minutes	-0.000108	0.00575	**-0.00106**	**-0.0106**
B_WAIT_SQ	Waiting time of taxi in minutes	0.0737	*-0.141*	/	**0.246**
Number of parameters		25	26	23	26
Number of observations		2922	5280	2346	5838
Number of individuals		487	880	391	973
LL null		-3210.145	-5800.673	-2577.344	-6413.699
Final LL		-2002.026	-3705.223	-1226.771	-3535.067
Rho square		0.376	0.361	0.524	0.449

Note: Estimates in bold are significant at $p<0.05$. Estimates in italics are significant at $p<0.10$.

2.2.3 Results of the latent class choice model

The previous section investigated the impact of attributes on the choice probability of each alternative. The estimated coefficients characterize the average preference profile of the sample. However, mode preferences are usually not homogeneous among the population. To explore possible preference heterogeneity and provide explanations underlying this heterogeneity, we estimated a latent class choice model for both cities. We choose not to present the estimated coefficients of these models in the report, which are replaced by more tangible descriptions. For each city, we first show the classification results and describe each class using the choice probability; it is then followed by the distribution of individual characteristics in each class, which sheds light on the influence of individual characteristics on class membership.

Amsterdam

For both the commute and non-commute experiment, three classes are identified. Table 7 lists the size and choice probability of each class.

For the commute trip, class 1 has a share of 52.8%. It is labeled "current mode" because respondents in this class chose the current mode 85.4% of the times and rarely chose the eHUB modes. Class 2 is labeled "Interest in shared EV" and takes 36.5% of the sample: it chose eHUB alternatives more than class 1 (around 30%) and prefers shared EV to e-bike (21.5%vs 9.2%). Class 3 is the smallest class having only 10.7% of the sample. This class is called "eHUBS" because it is likely to be the class that uses eHUBS the most often, only chose current mode in 43.5% of the choice tasks and seems to prefer e-bike to EV (35.8% vs 20.7%).

As for non-commute trips, class 1 has a share of 61.7%. It is also labeled "current mode" because it hardly chose shared EV or e-bike (only chose eHUB modes in 7.1% of the tasks). Class 2 is named as "eHUB" because it also chose the two eHUB alternatives for more than half of the times (63.1%). Although it is different from the eHUB class in the commute model since it chose shared EV much more often than e-bike (47.5% vs 15.6%). Class 3 is labeled "interest in shared e-bike" and its share is 16.9%: it chose current mode for slightly more than half of the time, and strongly prefers shared e-bike to EV (36.1% vs 7.8%).

Table 7. The choice proportion of alternatives in each class in Amsterdam

	Commute				Non-Commute			
	Total	Class 1 Current mode	Class 2 Interest in shared EV	Class 3 eHUB	Total	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared e-bike
Class size		52.8%	36.5%	10.7%		61.7%	21.4%	16.9%
Current mode	75.1%	85.4%	69.3%	43.5%	74.7%	92.9%	36.9%	56.1%
Shared EV	14.5%	8.4%	21.5%	20.7%	14.3%	4.6%	47.5%	7.8%
Shared e-bike	10.4%	6.2%	9.2%	35.8%	11.0%	2.5%	15.6%	36.1%

Table 8 shows the distribution of current mode in each class. We had ten different options for the current mode, and they are merged into four classes: "car" includes car driver, car passenger, motorbike, carsharing and taxi, "bike" consists of private bike, private e-bike and bike sharing.

Table 8. The mode share in each class in Amsterdam

	Commute				Non-Commute			
	Total	Class 1 Current mode	Class 2 Interest in shared EV	Class 3 eHUB	Total	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared e-bike
Car	45.0%	45.5%	42.7%	50.3%	42.6%	44.9%	44.4%	32.3%
Public transport	15.6%	14.5%	13.3%	28.9%	11.4%	10.7%	11.4%	13.7%
Bike	39.4%	40.0%	44.0%	20.8%	30.8%	29.7%	28.4%	37.6%
Walk	/	/	/	/	15.2%	14.7%	15.9%	16.3%

Note: / means not applicable because no respondent used the respective mode.

In the commute trip experiment, we did not recruit any respondents with their current mode as walking. The current mode class does not stand out with respect to mode distribution. “Interested in shared EV” class has the highest share of bike users while the eHUB class has the highest share of car and public transport users. In case of the non-commute experiment, the distribution of current modes of class 3 is significantly different from the total sample: it has the lowest share of car users and the highest share of public transport and bike users.

Table 9 presents the within-class distribution of individual characteristics of each class. If the group with a certain characteristic (e.g. males) are overrepresented (having a share larger than sample share) in class 2 or 3 (which are more likely to be the potential eHUBS users), this indicates that people with this characteristic have a higher chance of choosing eHUB modes. We will discuss the influence of each variable in turn.

Gender: for both commute and non-commute trips, the eHUB class has the highest share of males, indicating a stronger preference for eHUBS among males.

Age: young people between the age of 18-34 is overrepresented in both class 2 and 3, which implies that they are more likely to use eHUBS for both commute and non-commute trips. Middle-aged people (35-44) are more likely to use eHUBS for non-commute trips but not commute trips.

Education: People with high education degree are more likely to belong to both the “interest in shared e-bike” and “eHUB” classes in case of non-commute trip, but for commute trip only the “interest in shared EV” is overrepresented with people with high education.

Income: people with low income are more likely to belong to the “eHUB” class for the commute trip and the “interest in shared e-bike” class for non-commute trips, both classes prefer shared e-bike to EVs. On the contrary, people with high income have a higher chance of being the member of the “interest in shared EV” class for commute trip and “eHUB” class for non-commute trip, both classes prefer shared EV to e-bikes. As for people with middle level income, they are overrepresented in both eHUB potential user classes (“eHUB” and “interest in shared EV”) for the commute trip, but in case of non-commute trips they are only overrepresented in the “eHUB” class.

Employment: In case of the commute trip, the “interest in shared EV” class has the highest share of employed people, but the “eHUB” class has the highest share of people who commute at least 4 days a week. This is because there are a lot of part-time employed people in the “interest in shared EV” class. Students are overrepresented in the two eHUB potential user classes which prefer e-bikes to EVs (“eHUB” for the commute trip and “interest in shared e-bike” for non-commute trips).

Number of children: people with children are not deterred from using eHUBS since they are not overrepresented in the current mode class, but they are only overrepresented in the “eHUB” class which strongly prefer a shared EV over e-bike. This is intuitive since cars allow people to take passengers (children), although we did not ask the respondents to specify whether children are also present in the trips.

Vehicle ownership: for the commute trip, the “eHUB” class has the highest share of people with cars. The share of people with more than 1 car is also higher than the overall sample in the “interest in EV” class. As for non-commute trips, people with cars are only more likely to be a member of the “eHUB” class which prefers shared EV to e-bike, while the “interest in shared e-bike” class has the highest share of people without a car. In general, people with multiple cars are rather positive regarding using eHUBS.

Table 9. The within-class distributions of individual characteristics in Amsterdam

	Commute Total	Class 1 Current mode	Class 2 Interest in shared EV	Class 3 eHUB	Non-commute Total	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared e-bike
Gender								
• Female	54.4%	53.0%	57.4%	51.4%	54.1%	54.9%	50.8%	55.2%
• Male	45.6%	47.1%	42.6%	48.6%	45.9%	45.1%	49.2%	44.8%
Age								
• 18-24	20.3%	18.8%	21.0%	25.5%	16.0%	14.1%	20.2%	17.7%
• 25-34	31.4%	29.5%	33.8%	32.6%	27.4%	21.4%	43.7%	28.8%
• 35-44	21.6%	23.5%	20.0%	17.2%	19.3%	17.4%	23.2%	21.3%
• 45 or older	26.7%	28.1%	25.2%	24.7%	37.3%	47.1%	12.9%	32.2%
Education								
• No high education	33.3%	34.1%	30.0%	40.4%	39.5%	44.4%	34.0%	28.6%
• With high education	66.7%	65.9%	70.0%	59.6%	60.5%	55.6%	66.0%	71.4%
Income								
• Low	37.8%	39.1%	35.2%	40.1%	41.0%	41.8%	33.1%	48.2%
• Middle	34.1%	31.8%	35.7%	39.7%	32.6%	31.0%	43.3%	25.1%
• High	15.2%	15.1%	16.4%	11.5%	13.5%	12.1%	18.3%	12.7%
• Missing value	12.9%	14.0%	12.7%	8.7%	12.8%	15.1%	5.3%	14.0%
Job								
• Employed	79.1%	78.5%	81.0%	75.3%	71.1%	68.1%	76.6%	75.3%
• Student	11.1%	10.9%	11.1%	12.3%	8.4%	7.2%	7.5%	14.1%
• Others	9.9%	10.7%	7.9%	12.5%	20.5%	24.7%	15.9%	10.6%
Commuting days per week								
• Fewer than 3	21.1%	20.7%	23.3%	16.0%	33.0%	33.8%	37.8%	23.7%
• 4 or more	78.9%	79.3%	76.7%	84.0%	67.0%	66.2%	62.2%	76.3%
Number of children								
• 0	57.1%	57.2%	56.9%	57.3%	63.9%	70.9%	40.4%	68.0%
• 1	18.9%	19.3%	20.0%	13.2%	16.4%	13.8%	26.7%	12.9%
• More than 1	24.0%	23.6%	23.1%	29.5%	19.8%	15.4%	33.0%	19.1%
Number of cars								
• 0	17.7%	18.7%	18.2%	10.6%	17.5%	18.2%	8.9%	25.7%
• 1	63.0%	63.8%	61.4%	64.7%	65.0%	66.3%	67.2%	57.5%
• More than 1	19.3%	17.5%	20.4%	24.6%	17.5%	15.5%	23.9%	16.8%

Manchester

For both the commute and non-commute experiment, three classes are identified.
Table 10 lists the size and choice probability of each class.

For the commute trip, class 1 has a share of 48.8%. It is labeled "current mode" because it chose the current mode 93% of the time and rarely chose the eHUB modes. Class 2 is labeled "Interest in shared e-bike" and takes 35.1% of the sample: it chose eHUB alternatives more than class 1 (around 30%) and prefers shared e-bike to EV (19.2% vs 9.0%). Class 3 is the smallest class having only 16.1% of the sample. This class is called "eHUBS" because it is likely to be the class that uses eHUBS the most often, only chose current mode in slightly more than half of the choice tasks and seems to also prefer e-bike to EV (24.9% vs 19.7%).

As for non-commute trips, class 1 has a share of 57.3%. It is also labeled "current mode" because it hardly chose shared EV or e-bike (only chose eHUB modes in 7.1% of the tasks). Class 2 is named as "eHUB" because it also chose the two eHUB alternatives for more than half of the time (63.1%). Like the eHUB class in commute model, this class also chose shared e-bike much more often than EV (37.1% vs 12.3%). Class 3 is labeled "interest in shared EV" and its share is 18.4%: it chose current mode in 67.7% of the tasks, and strongly prefers shared EV to e-bike (29.1% vs 3.2%).

Table 10. The choice proportion of alternatives in each class in Manchester

	Commute				**Non-commute**			
	Total	Class 1 Current mode	Class 2 Interest in shared e-bike	Class 3 eHUB	Total	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared EV
Class size		48.8%	35.1%	16.1%		57.3%	24.3%	18.4%
Current mode	79.5%	93.0%	71.7%	55.4%	78.9%	95.0%	50.6%	67.7%
Shared EV	9.0%	5.4%	9.0%	19.7%	9.4%	2.1%	12.3%	29.1%
Shared e-bike	11.5%	1.6%	19.2%	24.9%	11.7%	2.8%	37.1%	3.2%

Table 11 shows the distribution of current mode in each class. We had ten different options for the current mode, and they are merged into four classes: "car" includes car driver, car passenger, motorbike, carsharing and taxi, "bike" consists of private bike, private e-bike and bike sharing.

In the commute trip experiment, we did not collect any respondent with current mode as walking. The current mode class does not stand out with respect to mode distribution. "Interested in shared e-bike" class has the highest share of public transport and bike users while the eHUB class has the highest share of car users.

In case of the non-commute experiment, the "current mode" class has the highest share of car users, which implies that car users are less likely to switch towards eHUBS compared to users of other modes. The share of people whose current mode is public transport or walk in both eHUB and Interest in shared EV classes are higher than the sample share, while bike users are only overrepresented in the eHUB class.

Table 11. The mode share in each class in Manchester

	Commute				**Non-commute**			
	Total	Class 1 Current mode	Class 2 Interest in shared e-bike	Class 3 eHUB	Total	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared EV
Car	81.6%	83.1%	77.7%	85.6%	70.7%	72.5%	66.6%	70.3%
Public transport	12.5%	10.4%	15.8%	12.0%	4.0%	3.3%	4.9%	5.2%
Bike	5.9%	6.5%	6.6%	2.4%	3.0%	3.1%	4.1%	1.3%
Walk	/	/	/	/	22.3%	21.1%	24.4%	23.2%

Table 12 presents the within-class distribution of individual characteristics of each class. If the group with a certain characteristic (e.g. males) are overrepresented (having a share larger than sample share) in class 2 or 3 (which are more likely to be the potential eHUBS users), this indicates that people with this characteristic have a higher chance of choosing eHUB modes. We will discuss the influence of each variable in turn.

Gender: for both commute and non-commute trips, the eHUB class has the highest share of males, indicating a stronger preference for eHUBS among males.

Age: Young people between the age of 18-24 are only overrepresented in the two classes which prefer shared e-bikes to EVs ("interest in shared e-bike" for commute trips and "eHUB" for non-commute trips). Those between the age of 25-34 are overrepresented in both class 2 and 3, which implies that they are more likely to use eHUBS for both commute and non-commute trips. Middle aged people (35-44) are more likely to use eHUBS for their commute trip but not non-commute trips.

Education: People with a high education degree are more likely to belong to both the "interest in shared e-bike" class for the commute trip and the "interest in shared EV" class in case of non-commute trips.

Income: people with low income are more likely to belong to the "current mode" class for both commute and non-commute trips, which suggests that they have relatively low interest in eHUBS. People with high income have a higher chance of being the member of the "eHUB" class for commute trip and the "interest in shared EV" class for non-commute trips: both classes prefer shared EVs to e-bikes.

Employment: In the case of the commute trip, the "eHUB" class has the highest share of employed people but the lowest share of people who commute at least 4 days a week. This is because there are a lot of part-time employed people present. Students are overrepresented in the two eHUB potential user classes which prefer e-bikes to EVs ("interest in e-bike" for the commute trip and "eHUB" for non-commute trips).

Number of children: people with children are not deterred from using eHUBS for non-commute trips since they are not overrepresented in the current mode class, but they are only overrepresented in the "eHUB" class which strongly prefer shared e-bike over EV. This is rather counter-intuitive since e-bikes may not easily accommodate passengers (children), although we did not specify whether children will be passengers in the experiment.

Vehicle ownership: for the commute trip, the "eHUB" class has the highest share of people with one car while the "interest in shared e-bike" class has the highest share of people with multiple cars. The share of people with more than 1 car is also higher than sample share in the "interest in EV" class. As for non-commute trips, people with multiple cars are more likely to be a member of both the "eHUB" and "interest in shared EV" class, while people with only one car is more likely to belong to the "current mode" class. In general, people with multiple cars are rather positive regarding using eHUBS.

Table 12. The within-class distributions of individual characteristics in Manchester

	Commute Total	Class 1 Current mode	Class 2 Interest in shared e-bike	Class 3 eHUB	Non-commute Total	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared EV
Gender								
• Female	60.9%	62.1%	61.1%	56.9%	58.6%	57.8%	57.2%	63.0%
• Male	39.1%	38.0%	39.0%	43.1%	41.4%	42.2%	42.9%	37.0%
Age								
• 18-24	11.8%	11.1%	14.3%	8.3%	10.6%	8.7%	16.3%	8.8%
• 25-34	31.7%	30.7%	32.9%	32.3%	27.6%	24.3%	35.0%	28.5%
• 35-44	30.4%	30.5%	26.9%	37.9%	25.5%	26.3%	23.7%	25.4%
• 45 or older	26.1%	27.7%	25.9%	21.6%	36.3%	40.7%	25.1%	37.3%
Education								
• No high education	39.9%	42.4%	36.3%	40.1%	35.7%	36.1%	38.7%	30.5%
• With high education	60.1%	57.6%	63.7%	60.0%	64.3%	64.0%	61.3%	69.5%
Income								
• Low	51.9%	53.0%	51.5%	49.6%	49.3%	51.0%	48.6%	44.9%
• Middle	35.0%	34.4%	37.0%	32.9%	37.5%	37.0%	37.6%	39.0%
• High	9.2%	9.7%	6.8%	12.8%	8.7%	7.1%	9.3%	13.0%
• Missing value	3.8%	2.9%	4.7%	4.7%	4.4%	4.8%	4.5%	3.0%
Job								
• Employed	81.1%	80.7%	78.8%	87.3%	72.1%	71.1%	71.0%	77.0%
• Student	7.4%	6.5%	8.7%	7.3%	7.4%	6.0%	11.1%	6.8%
• Others	11.5%	12.8%	12.5%	5.4%	20.5%	22.9%	17.9%	16.3%
Commuting days per week								
• 3 or fewer	15.6%	13.9%	14.9%	22.3%	29.3%	32.0%	22.5%	29.7%
• 4 or more	84.4%	86.1%	85.1%	77.7%	70.7%	68.0%	77.5%	70.3%
Number of children								
• 0	52.4%	51.3%	57.1%	45.8%	60.3%	61.1%	54.5%	65.7%
• 1	18.2%	19.6%	15.2%	20.3%	17.2%	16.4%	22.0%	13.2%
• More than 1	29.4%	29.1%	27.7%	33.9%	22.5%	22.5%	23.5%	21.1%
Number of cars								
• 0	5.6%	6.5%	5.2%	3.8%	4.7%	4.9%	4.3%	4.8%
• 1	44.5%	43.8%	40.9%	54.7%	43.7%	46.5%	41.2%	38.1%
• More than 1	49.9%	49.7%	53.9%	41.5%	51.6%	48.6%	54.5%	57.1%

2.3 The added value of eHUBS

We investigate the added value of eHUBS by analyzing the difference between the responses for the second and third questions (both "frequency questions"): how will people change their behavior when only one instead of two shared modes are available? Are people flexible regarding the choice between two shared modes?

Table 13 presents the distribution of choices in the three scenarios in each model: 1) when both a shared EV and an e-bike are available; 2) only shared EVs are available; 3) only shared e-bikes are available. In both Amsterdam and Manchester, the percentage of using the current mode is slightly lower when both shared EV and e-bike are available for both commute and non-commute trips. This is intuitive because the two modes are not entirely interchangeable.

Table 13. The choice proportion under eHUB and unimodal scenarios

	Amsterdam		Manchester	
	Commute	Non-commute	Commute	Non-commute
Current mode	71.8%	70.1%	79.1%	77.6%
Shared EV	15.3%	14.7%	9.5%	10.6%
Shared e-bike	12.9%	15.2%	11.4%	11.8%
Only Shared EV				
Current mode	75.6%	76.2%	84.6%	83.8%
Shared EV	24.4%	23.8%	15.4%	16.2%
Only Shared e-bike				
Current mode	73.6%	74.0%	82.7%	83.2%
Shared e-bike	26.4%	26.0%	17.3%	16.8%

Table 14 shows the distribution of choices of each class for the three scenarios in Amsterdam. The adaptation behavior is quite different between classes.

For the commute trip, the "current mode" class only demonstrates a slight increase in usage of the current mode when one mode becomes unavailable, which suggests that they are flexible between the usage of two shared modes. The "interest in shared EV" class also demonstrates a similar adaptation pattern as the "current mode" class, despite preferring EV over e-bike when both modes are available. On the other hand, the "eHUB class" only strongly increases the usage of current mode when e-bike becomes unavailable, implying that the shared e-bike can cover most trips they would have done by shared EV.

In the case of non-commute trips, the adaptation of the "interest in shared e-bike" class is similar to the "eHUB" class for the commute trip: shared e-bike can replace most trips conducted by shared EV but not *vice versa*. As for the "eHUB" class, the usage of current mode sharply increases when any of the shared modes becomes unavailable, probably because this class genuinely prefers using multiple shared modes.

Table 14. The choice proportion under eHUB and unimodal scenarios in each class in Amsterdam

	Commute			Non-commute		
	Class 1 Current mode	Class 2 Interest in shared EV	Class 3 eHUB	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared e-bike
Current mode	78.7%	69.0%	47.4%	84.0%	39.7%	57.6%
Shared EV	11.7%	19.3%	19.4%	8.5%	34.9%	11.9%
Shared e-bike	9.6%	11.7%	33.2%	7.5%	25.4%	30.5%
Only Shared EV						
Current mode	80.2%	71.3%	67.5%	85.4%	49.9%	75.9%
Shared EV	19.8%	28.7%	32.5%	14.6%	50.1%	24.1%
Only Shared e-bike						
Current mode	79.4%	71.6%	51.6%	85.3%	52.5%	59.7%
Shared e-bike	20.6%	28.4%	48.4%	14.7%	47.5%	40.3%

Table 15 shows the distribution of choices of each class for the three scenarios in Manchester. The adaptation behavior is quite different between classes.

For the commute trip, the usage of current mode of the "current mode" class only slightly increases when shared EV becomes unavailable and does not even change when shared e-bike is unavailable, which suggests that this class is rather flexible between the usage of two shared modes. The "interest in shared e-bike" class only strongly increases the usage of current mode when e-bike becomes unavailable, implying that the shared e-bike can cover most trips they would have done by shared EV. The "eHUB class" increases their usage of current mode sharply when either of the shared modes becomes unavailable, probably because this class genuinely prefers using multiple shared modes.

In the case of non-commute trips, both the "eHUB" and "interest in shared EV" class demonstrates a significant increase when either of the shared modes becomes unavailable which suggests preference for multiple shared modes. There is also a strong mode preference in the adaptation pattern: for the "eHUB" class shared e-bike can replace around half of the trips of conducted by shared EV but not vice versa, while for the "interest in shared EV" class it is the other way around: shared EV can replace half of the previous shared e-bike trips.

Table 15. The choice proportion under eHUB and unimodal scenarios in each class in Manchester

	Commute			Non-commute		
	Class 1 Current mode	Class 2 Interest in shared e-bike	Class 3 eHUB	Class 1 Current mode	Class 2 eHUB	Class 3 Interest in shared EV
Current mode	90.3%	73.3%	57.9%	90.8%	53.5%	67.0%
Shared EV	6.5%	9.8%	17.9%	4.6%	14.0%	26.7%
Shared e-bike	3.2%	16.9%	24.2%	4.5%	32.6%	6.3%
Only Shared EV						
Current mode	90.3%	83.3%	69.8%	92.1%	73.3%	70.1%
Shared EV	9.7%	16.7%	30.2%	7.9%	26.7%	29.9%
Only Shared e-bike						
Current mode	91.7%	77.4%	66.7%	92.1%	59.2%	87.5%
Shared e-bike	8.3%	22.6%	33.3%	7.9%	40.8%	12.5%

3. CONCLUSION

We conducted two surveys regarding people's intention and preferences for the shared mobility service eHUBS. Several statistical models were applied in analyzing the response data. The main conclusion of our analyses are as follows:

- The choice of eHUB usage is significantly influenced by attributes such as access time, parking time and parking cost. Travel time and cost variables are not always significant in the short trip setting. Public transport users are more likely to switch to eHUBS compared to car users while private bike users are less likely.
- Many sociodemographic variables (such as gender, age, education, income), mobility related variables (vehicle ownership and the current mode) and attitudes (pro-shared mobility, perception of the barriers for shared mobility usage) can explain the difference in eHUB preferences and the intention to use. For example, persons between the age of 18-34 or with higher education degree are found to have a stronger preference for eHUBS. Moreover, stronger pro-shared mobility attitude and perception of the barriers regarding shared mobility use predict higher intention of using shared mobility.
- Providing two modes in eHUBS can increase the usage of shared mobility in contrast to unimodal shared mobility services. If one mode (shared EV or e-bike) becomes unavailable, the choice probability of using eHUBS has a 1.8-6.2 percentage point decrease (depending on the city and trip purpose). The adaptation pattern when one shared mode becomes unavailable also differs between classes with distinct preference profiles.

References

Li, W., Kamargianni, M.: Steering short-term demand for car-sharing : a mode choice and policy impact analysis by trip distance. Springer US (2020)

Reck, D.J., Guidon, S., Haitao, H., Axhausen, K.W.: Explaining shared micromobility usage, competition and mode choice by modelling empirical data from Zurich, Switzerland. Transp. Res. Part C. 15, 12–19 (2020). doi:10.1016/j.trc.2020.102947

Appendix

Table A-1 Sample demographics (counts and percentages), RG = Reference Group

Variable	Categories	Count (n)	Percent (%)
Age	18 to 24	287	11.5
	25 to 34	620	24.9
	35 to 44	551	22.1
	45 to 54	468	18.8
	55 to 64	337	13.5
	65 to 74	179	7.2
	75 or older (RG)	49	2.0
Gender	Male	1312	53.4
	Female	1127	45.9
	Other (RG)	16	0.7
Country	Netherlands	761	30.7
	Germany	478	19.3
	Belgium	441	17.8
	England	404	16.3
	France	387	15.6
	Other (RG)	7	0.3
Number of adults*	1	735	29.9
	2	1243	50.6
	3	253	10.3
	4 or more (RG)	226	9.1
Number of children	0	975	52.6
	1	348	18.8
	2	366	19.8
	3 or more (RG)	163	8.8
Education	Post- or under-graduate studies	1675	67.5
	School education	430	17.3
	Professional qualification (non-academic)	291	11.7
	No school education	15	0.6
	Prefer not to say (RG)	73	2.9
Income	< £20,000	392	15.8
	£20,000-£39,999	644	25.9
	£40,000-£59,999	502	20.2
	£60,000-£79,999	272	10.9
	£80,000-£99,999	139	5.6
	> £100,000	103	4.1
	Prefer not to say (RG)	435	17.5