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Smart Mobility Hubs as Game Changers in Transport

WP5. Impact assessment of SmartHubs Living Labs
T5.1. Mobility hubs and virtual and physical mobility needs and patterns

SmartHubs Deliverable D5.1 Mobility hubs impacts on mobility patterns and behavioural change

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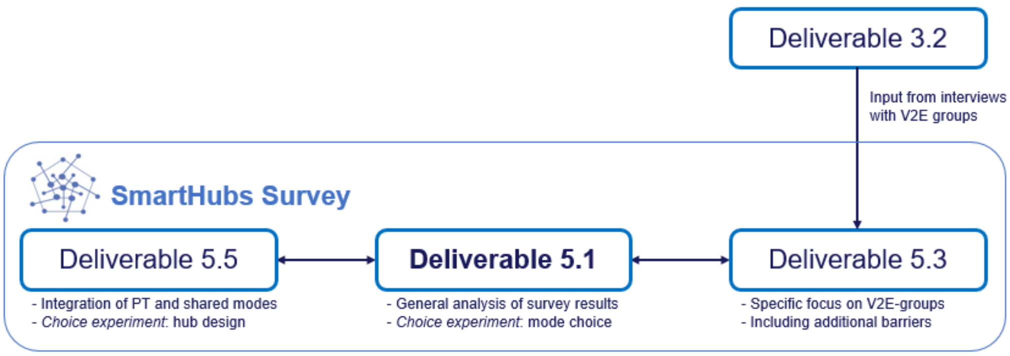
EXECUTIVE SUMMARY

Mobility hubs are destined to offer multiple mobility services that can accommodate various mobility needs of different population groups. By increasing the availability and providing tailored design of the services, mobility hubs can enhance the accessibility and resilience of mobility networks. Evaluating the hubs' effectiveness in increasing mobility accessibility and sustainability requires investigating the changes that are provoked by their addition to the mobility network. The present Smarthubs deliverable presents an impact analysis of mobility hubs on current and future mobility patterns and quantifies changes in travel behaviour, especially in mode choice behaviour. The study depends on the analysis of data from the Smarthubs standardised survey. The data collection lasted from December 2023 to February 2023 in four urban areas: Brussels Capital Region (Belgium), Munich (Germany), Vienna (Austria), and Rotterdam/The Hague (the Netherlands), and in the rural areas of the Lower Austria region. By exploiting the sample of 2516 survey respondents, the analysis provides insight into the overall potential of mobility hubs as game changers of mobility behaviour and the existence of similarities and disparities on an international level.

Shared mobility is an integral part of mobility hubs. The analysis of the survey respondents' familiarity with shared modes (bike, e-scooter, car, moped) reveals that around one third of the individuals have already travelled by one or more mobility services. Moreover, modes' popularity and usage frequency varies among the study areas. Nevertheless, the conduction of Latent Class Analysis uncovers that the typical shared mobility users are so-called "mobility chameleon" that are not only dependent on shared mobility but alternate and combine various shared, private and public transport modes to satisfy their travel needs. Higher digital mobility skills and income are consistently positively correlated to the probability of belonging to the "mobility chameleons" cluster. Regardless of the cluster class that people currently belong to, they indicate an increased interest in travelling by shared mobility in the future. The findings suggest that although most of the current hub-based shared mobility trips could be conducted by public transport and active modes, one third of the trips replace private car trips. People appear to be more or less attracted to the various mobility hubs modes, depending, among others, on their established travel habits. For instance, frequent private car users are more interested in bike than car sharing. The results from a mode choice stated preference experiment also support that mobility hubs can trigger changes in mode preference, and consequently in modal split. Nevertheless, diverse factors, including mode (e.g. speed, cost) and trip characteristics (weather, trip purpose) as well as sociodemographic characteristics such as age and gender influence the attractiveness of hub-based modes.

Relation to other SmartHubs deliverables

The relationship between the "Mobility hubs impacts on mobility patterns and behavioural change" (Deliverable 5.1) and other SmartHubs deliverables is visualized in the diagram below. D5.1 explains the design and data-gathering process of the survey, and focuses on mobility patterns, hubs user profiles and mode choice behaviour changes due to the introduction of mobility hubs. D5.3 explicitly focuses on the pre-defined (vulnerable to exclusion (V2E) groups and analyses the survey results from the perspective of those groups. D5.3 uses input from D3.2 regarding barriers and needs of V2E groups. D5.5 explicitly focuses on hubs' design and people's willingness to pay for different hub elements.



1 INTRODUCTION

This chapter introduces the context and content of this deliverable, its connection with the Smarthubs project objective and other deliverables, and describes the locations on which the report focuses.

1.1 Potential impacts of mobility hubs

Several cities in Europe are currently implementing new shared modes such as shared cars, bikes as well as scooters, and are promoting public transport and active modes to reduce the usage of private cars. To make the various mobility services more accessible by connecting the different transport options, the concept of mobility hubs has been introduced. Ideally, in a mobility hub public transport and multiple shared modes such as shared bikes and shared cars should be present. The hubs should have a dedicated space that also facilitates more mobility infrastructure such as parking of private vehicles. Additionally, non-mobility facilities such as repair, eating, shopping and logistic pick-up points should be added to increase the attractiveness and efficiency hubs.

In most guidelines for mobility hubs, a commonly appointed phrase is that “hubs should be designed to be accessible to all users”. However, no particular definition of different transport users and their needs is available in most literature sources. Even those mentioning specific target groups, still tend to mainly address the total of the population and avoid facing needs and preferences of different population segments. Hub characteristics like their location, the pricing policy, and the services provided can determine the accessibility of the hub to the entire population. Overall, it is essential to avoid practices and plans which only favour those who already have increased access to transport services or technology (Fleming, 2018).

A few recent studies have already investigated the impacts of mobility hubs. For example, one study based on user surveys in three German cities, Munich (Münchner Freitheit), Würzburg and Offenburg, showed that after the introduction of hubs, people became overall more aware of the sharing transport systems and their possibilities. With respect to modal shift, findings indicate that travellers increased the usage levels of car-sharing and public transport due to mobility stations (Miramontes, et al., 2017; Miramontes, et al., 2019). Past research indicates that various factors affect the use and corresponding effect of mobility hubs. Apart from individual characteristics, current travel behaviour also affects the preparedness and interest in using newly implemented mobility systems. For instance, public transport and bicycle users have been found as early adopters (Zijlstra, et al., 2020) and were identified as the most frequent users of e-mobility services (Liao & Correia, 2020). Similarly, researchers have found that the frequency of car trips influences the potential use of sharing systems (Tsouros, et al., 2021). Based on the findings of the literature, a multidimensional typology for mobility hubs has been developed in the Smarthubs project covering three dimensions: the physical, digital and democratic integration (SmartHubs integration ladder). Each dimension has 5 levels enabling the comparison of different hubs with different services in order to analyse potential effects. A mobility hub should offer a minimum level of integration and has at least level 1 on physical integration, digital and/or democratic integration. The higher up the ladders, the “smarter” the mobility hub becomes; thus, the hypothesis is that the “smarter” the mobility hub, the more user value is created, higher usage and user satisfaction levels can be achieved and increased societal impacts can be expected in terms of reduced car use and ownership levels, accessibility impacts, impact transport emissions, etc. Further details of the existing literature’s suggestions on the determinants of hubs usage and the SmartHubs integration ladder can be found in SmartHubs Deliverable D2.1. (Geurs, et al., 2022).

Despite findings like those above, it is still unclear how mobility hubs change and could further change mobility behaviour. The scarce available literature deals with the preliminary analysis of current users of mobility hubs, often based on pilot schemes, and the exploration of how individual characteristics affect the present mobility behaviour and hubs usage. Up to date there is very limited knowledge on the degree that hubs influence mobility behaviour and under which circumstances the hubs’ impact could become a sustainable alternative to private car usage and increase overall accessibility and equity in the mobility system. Finally, the role of landscaping as well as additional non-mobility services offered at mobility hubs, e.g. shelters, seating etc., and their influence to people living near mobility hubs has been neglected. In the SmartHubs project, these knowledge gaps are addressed based on the SmartHubs integration ladder and considered in the development and analysis of the SmartHubs standardised survey that was conducted in all project living labs. Findings of the survey are presented in this deliverable, focusing on mobility effects and needs, as well as in D5.3, SmartHubs Equity Assessment (Garritsen, et al., 2023) and D5.5, Integration of mobility hubs and public transport (Grigolon, et al., 2023). The three deliverables aim to provide an in-depth answer to the potential of mobility hubs. The present D5.1 addresses the conditions that could make mobility hubs a behavioural game changer.

1.2 Location and goals of the Smarthubs Living Labs

In the course of the SmartHubs project, living labs were selected in four European regions to investigate their impact in terms of physical, digital and democratic integration of mobility hubs. With the exception of the municipality of Pillichsdorf in Lower Austria, the rest are located in urban contexts (see Figure 1-1, Figure 1-2). The four living lab locations are as follows:

- Brussels Capital Region: One mobility hub located at Place du Conseil (Raadsplein), at the heart of the area of Cureghem in the municipality of Anderlecht.
- City of Munich: An existing parklet in the area of the Technical University was transformed into a mobility hub providing barrier-free access within 100 meters of the nearest public transport stop.
- Eastern Austrian region: Two mobility hubs located in new urban development areas in the City of Vienna (2nd and 22nd district) and one mobility hub in Pillichsdorf in Lower Austria.
- Metropolitan Region Rotterdam - The Hague: One mobility hub at the bus and metro station Zuidplein in Rotterdam and one located at Hobbemaplein in The Hague.

The interested reader can find further information on the characteristics of the living labs defined in the SmartHubs project can be found in the individual Living Lab Implementation Reports (Kirchberger, et al., 2023; Martinez, et al., 2023; Garritsen, et al., 2023; Duran-Rodas, et al., 2023).

All living labs are part of a broader network (currently or planned), with the goal to bridge existing gaps in the mobility service and to achieve valuable impacts on the mobility behaviour of residents of the particular areas. Mobility strategies have been developed in all project areas defining particular goals:

- Around 100 multimodal stations in total are planned in the City of Vienna until 2025 (OTS, 2021). The initiative "Mobility.Lab in Lower Austria" is aimed to develop and test new mobility solutions in particular in rural context in Lower Austria (Amt der NÖ Landesregierung, 2023).
- According to the “GoodMove Plan” the Brussels Capital Region plans the implementation of 20 hubs in the city by 2025 (Brussels Regional Public Service, 2020).
- Several types of hubs are implemented in the municipality of Rotterdam, already demonstrating the potential of shared vehicles as first- or last-mile modes for public transport (Gemeente Rotterdam, 2020; Gemeente Rotterdam, 2021). The Mobility Transition Strategy of The Hague mentions mobility hubs as a tool to increase use of public transportation (Graf & Hansel, 2023; The Hague, 2022).
- The mobility strategy for the year 2035 of Munich includes mobility hubs scattered throughout the city. The city aims at having 200 mobility hubs added to the 17 existing “Mobilitätspunkte” under operation (Landeshauptstadt München, 2023).

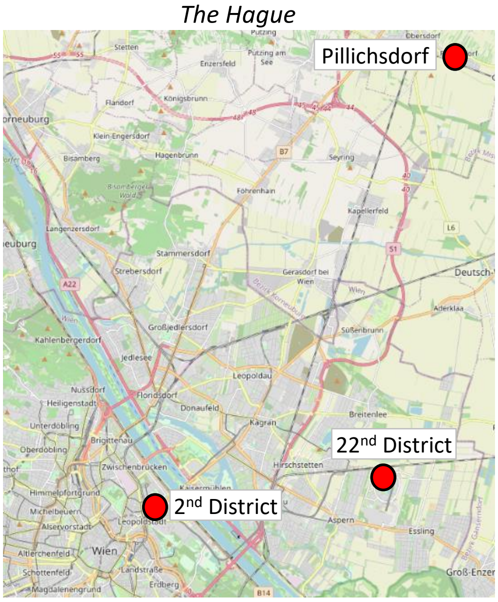
In light of the ambitious plans for an extensive deployment of mobility hubs, knowledge of their impact on mobility behaviour is essential in order to enable a targeted and efficient choice of location and design.

Figure 1-1. Location of the four living labs

Living Lab in the Brussels Capital Region

Living Labs in the Metropolitan Region Rotterdam – The Hague

Living Lab in Munich



Living Labs in the Eastern Austrian region

Figure 1-2. Location of the living labs at site

1.3 Structure of the deliverable

This report is divided into five chapters. After this introduction to the deliverable's objectives and context, we describe the survey data on which the impact analysis was based. Specifically, we describe the data collection design and process (chapter 2). In chapter 3, we investigate the present role of mobility hubs in the four living labs by describing the mobility hubs' user profile and the characteristics of hub-based trips. The fourth chapter focuses on the impact assessment of mobility hubs regarding present mode substitution effects and potential future mode shift. Finally, the report concludes with a summary on the main findings and a reflection on mobility hubs' current and future impacts.

2 DATA COLLECTION DESIGN

2.1 Survey design

This chapter describes the standardised survey of the SmartHubs project that provided the necessary data to analyse the impacts of mobility hubs across the four study areas in the context of the living labs.

2.1.1 Survey content

The survey design aimed at gaining insight into the characteristics (sociodemographic, mobility, and environment) of current and potential users of mobility hubs as well as on people's barriers and willingness to use mobility hubs under various circumstances. The survey explored all three dimensions (physical, digital, and democratic) of the SmartHubs integration ladder. The survey design was divided into the seven sections (Figure 2-1). All respondents, faced all sections with some variance depending on survey logic.

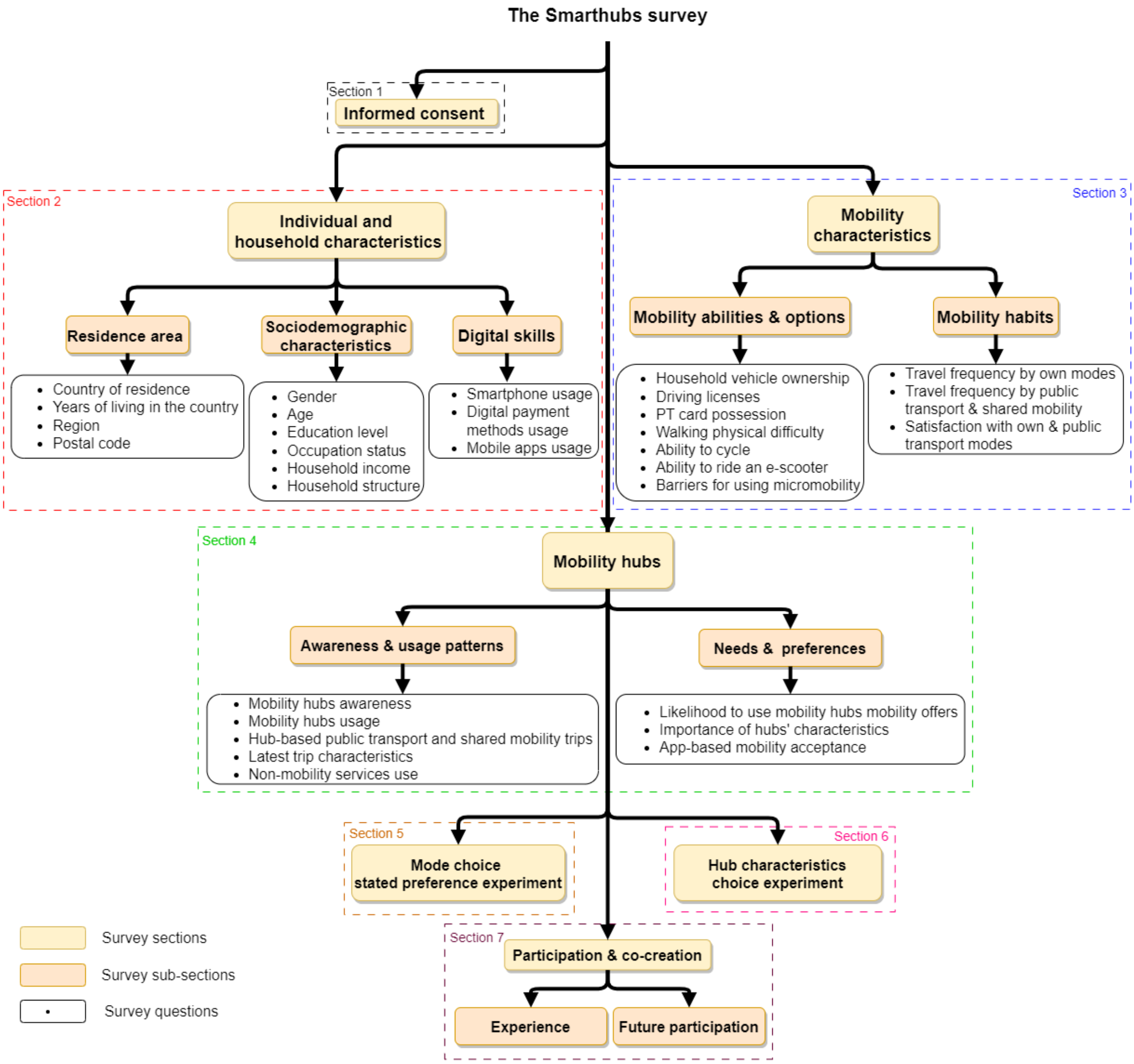


Figure 2-1. Overview of SmartHubs standardized survey content

The first section introduced respondents to the context of the survey and described the data protection policy of the collected data. Proceeding to the next sections was possible only after signing an online informed consent. Sections 2 and 3 collected information on multiple potential determinants of accessibility and usage of mobility hubs. In specific, Section 2 focused on individuals' sociodemographic characteristics and their digital skills. Concerning sociodemographic characteristics, the survey collected data both on individual level such as age, gender, and education level, and on their household (e.g., income, composition).

In SmartHubs analyses, digital mobility skills are defined via people's affinity with smartphone usage. As more and more emerging shared mobility services become available via smartphone apps, it has become crucial to investigate the preparedness of the current population for transition to app-based mobility. In the context of the survey design and the SmartHubs project the definition of digital mobility skills builds upon the measure of (Horjus, et al., 2022). The measure specifies four levels of digital skills levels, as follows:

- Level 0 (No skills). People in this category have no access to a smartphone.
- Level 1 (Low skills). Individuals have previous experience with smartphone usage but do not exploit their smartphone for planning activities such as their trips.
- Level 2 (Medium skills). People in this category are familiar with planning, but are inexperienced with digital, online payments via apps.
- Level 3 (High skills). In the highest level, individuals are acquainted with both planning and payment apps, including transferring money.

To capture digital mobility skills, the survey contained three different questions. In the first question, the survey respondents reported their possession or not of a smartphone ("Do you possess a smartphone?"). The second and third question of the digital skills section addressed smartphone users (Levels 1-3) and non-users (Level 0), respectively. The survey prompted non-users to indicate their familiarity with various digital payment methods that are not smartphone-bound such as debit card payment. Although this additional information does not distinguish people in a separate category, it allows capturing whether these people are acquainted with card-based mobility services. The third question of the section addressed smartphone holders and asked their usage of various smartphone apps, including apps for trip planning, online payment etc. Their responses to this question enabled their assignment to one of the digital mobility skills levels (Levels 1 to 3).

The third survey section concentrated on current mobility abilities and habits (Figure 2-1). The abilities subsection focused on respondents' physical abilities, e.g. walking difficulty, ability to cycle and ride e-scooter, as well as on their capabilities such as driving a car and motorcycle/moped. Moreover, in this part of the survey people also declared the (un-)availability of different transport modes in their household. To obtain information on peoples' mobility habits and preferences in the existing mobility system, the survey asked participants to reveal their travel frequency by vehicles they possess, by public transport and shared modes. Considering that shared mobility is an integral part of the current and future mobility hubs, the analysis of the data collected on the usage of various shared mobility services (bike, e-scooter, moped and car sharing) could provide insight into the people's familiarity with hubs-related mobility options. Apart from current habits, Section 3 also questioned the reasons that have restrained people from using shared mobility (non-users), referred to as barriers. Among the factors investigated were the services' costs, the availability and accessibility of vehicles and the offered information on how to access and use sharing services.

Sections 4 to 6 focused on the concept of mobility hubs and investigated current and potential needs and preferences from the design of hubs. In specific, Section 4 aimed at providing data on the current awareness and usage cases of mobility hubs in the various living lab locations. After identifying non-users and users of mobility hubs, the survey prompted the latter to provide detailed information on their hub-based trips (trip purpose, trip duration, and modes sequence). To identify patterns in mode selection, respondents also indicated the percentage of their trips by public transport and shared mobility trips that started or ended at mobility hubs. Moreover, the survey requested people to answer which mode they would have used for their latest hub-linked trip in case the hub was absent. Apart from the usage of mobility services, the participants reported whether they have ever used any additional service such bike repair equipment and e-vehicle charging stations. The second part of the section investigated people's needs and preferences for future mobility hubs. While the first question asked how likely it is that they travel by various mobility options in future hubs, the second question examined the importance of different hub design characteristics. These two questions covered the same topics with the two experiments of the next two sections. However, while these questions in Section 4 examined the population's unconstrained preferences from mobility hubs, the experiments of Section 5 and 6 captured respondents' choices under various hypothetical scenarios that involve charging costs for the usage and availability of mobility and non-mobility services of hubs.

The mode choice stated preference experiment in the fifth section examined whether people would be willing to shift to a mobility hub-based mode in case public transport and three different sharing services were available (bikes, e-scooter, cars) at the hub. To identify the factors that could determine the probability of changing or not, the experiment scenarios varied in terms of the travel modes characteristics such as travel time, access time and cost. A more detailed description on the experiment design is offered in chapter 2.1.2 of this report. The choice experiment on hub design (Section 6) investigated people's willingness to pay for different levels of the physical and digital dimension of the SmartHubs integration ladder. Unlike the mode choice experiment, this experiment focuses on preferences not only over mobility services but also over placemaking and landscape design of a hub. The detailed design of this experiment is presented in the Smarthubs Deliverable D5.5, Integration of mobility hubs and public transport (Grigolon, et al., 2023).

The survey concluded with a set of questions on people's involvement in co-design and participation processes for mobility issues in their area of residence. Considering that based on the Smarthubs integration ladder, smart mobility hubs are achievable only via the consideration of people's needs and preferences, their participation and activation is necessary during all design phases of mobility hubs. To obtain insight into the preparedness of the population to get involved in plans on mobility hubs the final survey section (Section 7) asked respondents' experience and familiarity with such processes and their willingness for future participation.

2.1.2 Mode choice stated preference experiment design

The experiment design aimed at answering the following three research questions:

a) How does the introduction of mobility hubs change existing mobility habits regarding transport mode selection?
b) Under which trip circumstances would people be willing to shift from their own car to car sharing or shared micromobility?
c) Which factors influence the attractiveness of shared mobility and public transport and, consequently, of mobility hubs?

For the experiment design, we reviewed the potential determinants of mode choice. The review of past studies on mode choice behaviour reveals at least five different groups of parameters that influence mode choice: (I) individual characteristics, (II) built environment variables, (III) trip characteristics, (IV) trip circumstances, (V) mode characteristics. To develop the present experiment, we focused mainly on the last group (mode characteristics). In specific, the experiment attributes included three time-components: travel time, access time, and waiting time. Travel costs and payment method were considered as well. Individual characteristics were captured earlier in the survey (see Figure 2-1).

Considering that the experiment targeted at capturing changes in mode choice behaviour, it was decided to include in the mode choice set both, "conventional" and emerging hub-based modes. The first group consisted of own car and the two typical active modes (walking and own bike) whereas shared bike, e-scooter or e-moped and car sharing were included in the second group, of emerging modes. Public transport could be characterised as both, a conventional and emerging mode depending on the service design and characteristics. Based on the definition of mobility hubs in the context of the Smarthubs project, public transport is a fundamental component of hubs, see Table 2-12 The SmartHubs integration ladder in (Geurs, et al., 2022). Therefore, in the experiment design it was considered as a hub-based service.

The survey also gathered data on trip characteristics based on a set of questions presented before the scenarios. Before facing the scenarios, survey participants reported their latest trip by one of four conventional modes: their own bike or car, walking, and public transport. The respondents could mention a trip by any of these modes with the prerequisite that its distance was between 0.5 km and 10 km. For this reference trip, people indicated the travel distance, the trip purpose and the travel circumstances (weather conditions and travel companions). The usage of the reference trip method increased the flexibility and adaptability of the scenarios to better imitate a trip familiar and realistic for the respondents. Consequently, it was expected that this method could assist in reducing the bias induced by assumptions made by the experiment participants.

All of the incorporated modes diverge in terms of their main characteristics, e.g., travel speed or costs. To build the experiment scenarios, it was necessary to vary the attribute values per mode of transport. Due to the large design of the experiment (seven modes and five attributes) and the need to consider respondents' burden, different number of levels and attributes were chosen for each mode. Since the focus was on hub-modes acceptance, we incorporated higher level of detail and more variance in the characteristics of shared and public transport alternatives. For all attributes, one of the levels represents the most common value in current trips by the specific modes. For time and cost variables, Level 1 and Level 3 are the most and least favourable scenario values, respectively (Table 2-1).

Table 2-1. Mode choice experiment attributes and levels per mode

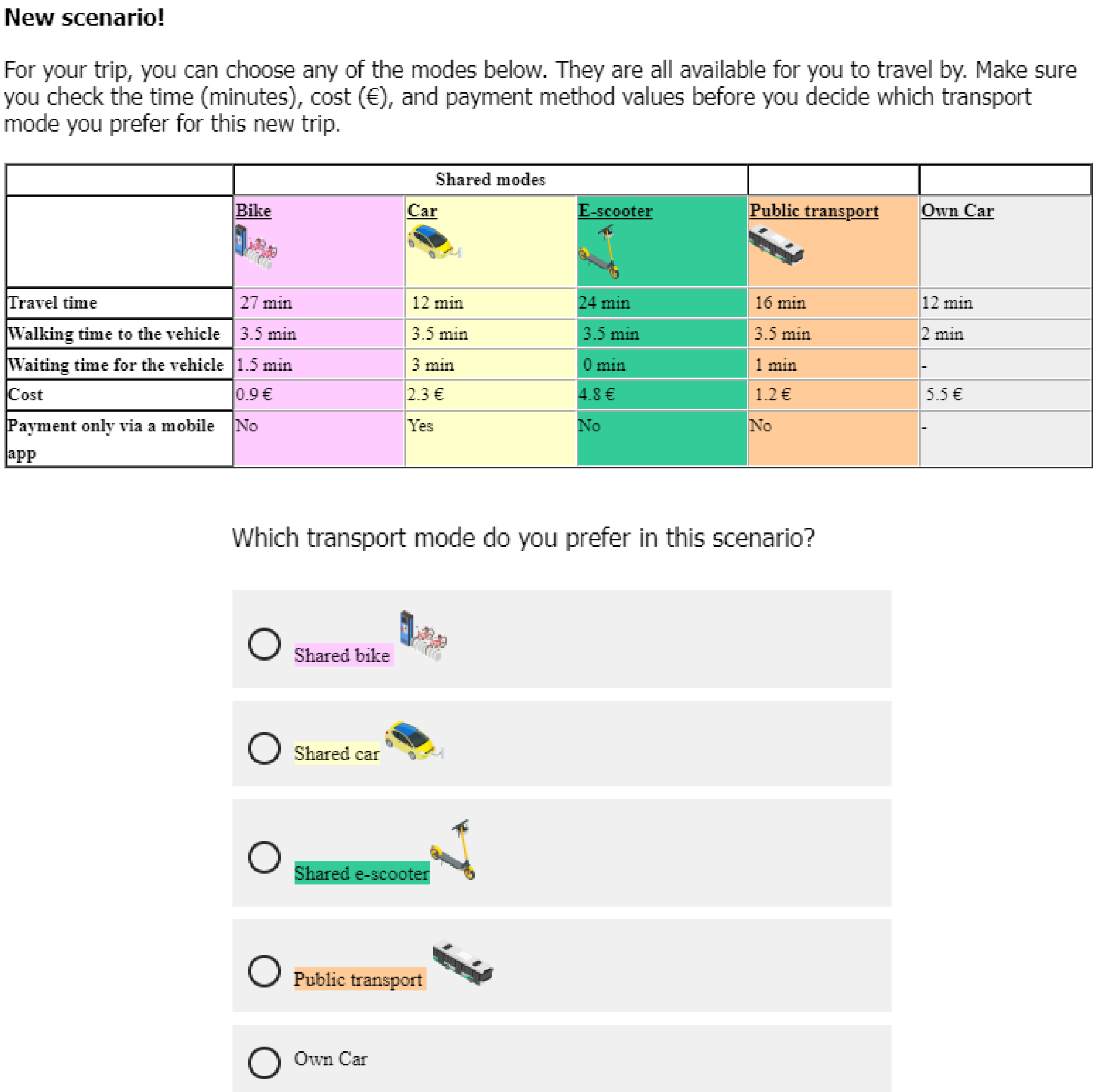
Alternative	**Attribute**	**Unit**	**Level 1**	**Level 2**	**Level 3**
Own car	Travel costs	Euro/km	0.7	1.1	
Shared bike	Travel speed	Km/hr	18.9	14.5	11
	Travel costs	Euro	0.3	0.6	0.9
	Waiting time	min	0	1.5	3
	Access time	min	1	3.5	6
	Payment via app only	-	Yes	No	-
Shared e-scooter/e-moped	Travel speed	Km/hr	16.5	12.5	9.5
	Travel costs	Euro/min*	0.1	0.2	0.3
	Waiting time	min	0	1.5	3
	Access time	min	1	3.5	6
	Payment via app only	-	Yes	No	-
Shared car	Travel speed	Km/hr	24.2	19.5	14.6
	Travel costs	Euro/min*	0.15	0.3	0.45
	Waiting time	min	0	1.5	3
	Access time	min	1	3.5	6
	Payment via app only	-	Yes	No	-
Public transport	Travel speed	Km/hr	25.5	18.3	14.8
	Travel costs	Euro	1.2	2.4	3.6
	Waiting time	min	1	5	9
	Access time	min	1	3.5	6
	Payment via app only	-	Yes	No	-

* For car, e-scooter and e-moped sharing, charging per minute is the most common existing practice and is followed in the present experiment.

As seen in Table 2-1, for the emerging, mobility hub modes, the time and cost attributes varied across three levels whereas for the payment method a binary variable was used. It should be mentioned that in Table 2-1 instead of the vehicle travel time attribute, travel speed is presented. Travel time was calculated during the survey completion, based on the selected speed values and the travel distance reported by each respondent. For the two active modes, their attributes remained constant across the scenarios whereas for own car only travel costs varied between two levels. While the usage of different attributes and number of levels per mode influences the number of observations per attribute/level/mode combination, it was an essential compromise to ensure the feasibility of the experiment design and its presentation to the participants.

In each choice set, respondents faced a selection among five alternative modes. More specifically, they could select between their reference mode, and four hubs modes: public transport and three sharing modes. Shared bike and car were present in all choice sets. Since shared e-scooters are currently prohibited in the Netherlands, they are only present in the experiment for the other three study areas (Eastern Austria, Brussels Capital Region, and Munich). In the version of the experiment for the Dutch living lab, e-moped sharing was added instead. While shared e-mopeds schemes are also in operation in the other three areas, adding mopeds as a sixth alternative would severely increase the complexity of the experiment both in terms of computational effort and respondent burden. Considering the higher popularity of e-scooter sharing in these regions, it was decided to entail e-scooter sharing in the mode choice set. Finally, for public transport reference trips people could select among four modes, as their reported mode is already a mobility hub mode.

The experiment design was optimised for efficiency and the final product entailed 72 scenarios per reference mode, divided into 12 blocks of 6 choice sets. Individuals were randomly assigned to one of the 12 blocks and faced in total six hypothetical scenarios for a future trip with similar characteristics to their reference one. Figure 2-2 shows an example choice set for the mode choice experiment. The example is from a respondent who mentioned a reference trip by own with a trip length of 5 km.


New scenario!

For your trip, you can choose any of the modes below. They are all available for you to travel by. Make sure you check the time (minutes), cost (€), and payment method values before you decide which transport mode you prefer for this new trip.

	Shared modes				
	Bike	Car	E-scooter	Public transport	Own Car
Travel time	27 min	12 min	24 min	16 min	12 min
Walking time to the vehicle	3.5 min	3.5 min	3.5 min	3.5 min	2 min
Waiting time for the vehicle	1.5 min	3 min	0 min	1 min	-
Cost	0.9 €	2.3 €	4.8 €	1.2 €	5.5 €
Payment only via a mobile app	No	Yes	No	No	-

Which transport mode do you prefer in this scenario?

- Shared bike
- Shared car
- Shared e-scooter
- Public transport
- Own Car

Figure 2-2. Mode choice stated preference experiment- choice task example

2.2 Data collection process

The following two sections describe the minimum sample requirements of the survey data and the procedure followed to achieve the defined goals.

2.2.1 Sample requirements

The goal of the joint SmartHubs survey was to get more (quantitative) understanding of the current and potential use of mobility hubs, and the importance of different integration levels of the hub itself. To reach these objectives, we defined four analysis themes prior to the data collection, as follows:

- Capture mobility behaviour of users and non-users of shared mobility,
- Exam mode choice shift induced by mobility hubs,
- Identify the conditions under which mobility hubs provoke mobility behaviour change,
- Evaluate the impacts of mobility hubs in regards to accessibility and wellbeing for different population segments, and especially vulnerable-to exclusion groups such as age, ethnic minorities, low-income, refugees, with lower digital mobility skills segments of the population.

To enable the above-mentioned analysis across the different living labs the survey, data should on the one hand be representative for the population and on the other hand allow in-depth analysis on vulnerable groups. Therefore, based on the sociodemographic characteristics of the population groups of interest and the SmartHubs objective on equity analysis, minimum sample requirements were defined prior to the data collection (Table 2-2).

Table 2-2. Sample requirements as planned for data collection

	Eastern Austria Region	**Brussels Capital Region**	**City of Munich**	**Metropolitan Region Rotterdam – The Hague**
Sample size	min. 500 respondents per region			
Females	50%, min 100 respondents per region			
Older than 65 years	~4%, min= 100 respondents	~7%, min 35 respondents	~12%, min 60 respondents	~ 10%, min= 50 respondents
Low education	~11%, min= 50 respondents	100 respondents	100 respondents	50%, min= 200 respondents
Low digital mobility skills	25 respondents per region			
Low-income	20%, min= 100 respondents	50%, min= 200 respondents	100 respondents	50%, min= 200 respondents

2.2.2 Data collection sources and survey area

Due to the quotas we set for multiple sample characteristics a stratified sampling method was chosen. The stratified sample should ensure that sufficient data are collected for all groups of interest (Table 2-2). As the four Smarthubs living labs are part of a broader network (current or planned) proper study areas were selected in which respondents were recruited and the survey launched.

<u>Eastern Austria Region</u>

While the total area of Vienna was targeted for data collection, in Lower Austria the focus was only on rural areas. To achieve the sample requirements a panel company was commissioned for the data collection in December 2022 for a collection period of two weeks. Additionally, an open invitation to complete the survey online was disseminated via social media (until February 2023). Moreover, data were also collected via assisted interviews in an event organized in Pillichsdorf in Lower Austria on 31st January 2023. The main goal of this event was to recruit people who have difficulties in filling in an online survey.

Brussels Capital Region

The survey was accessible from December 2022 to March 2023 for residents of the Brussels Capital Region. Most participants (n=471) were recruited by an external organisation which is specialised on survey panels. 118 respondents were recruited on the street between the 19 December and 31 January, and through social media posts of the Mobilise research group and the SmartHubs project. Some of the participants recruited on the street were assisted by a researcher when conducting the survey.

Metropolitan Region of Rotterdam – The Hague

The impact analysis focused on the Metropolitan Region Rotterdam – The Hague which apart from the two cities, also entails smaller cities which are well-connected to The Hague and Rotterdam. This extended study area allowed for a larger sampling population in quite a homogenous area. From the end of December 2022 until the end of January 2023, 84% of the responses were recruited via a survey panel company, the remaining part were collected via Dutch partners, e.g., shared mobility providers sharing the survey link after a ride was finished, sharing the survey link on social media of municipalities or the online platform of local neighbourhoods, as well as by performing assisted surveys in four community centres/libraries in Rotterdam and The Hague.

Munich

In the Munich Metropolitan Region data were collected via a panel company. In total, the panel members provided 138 answers. Most responses were collected in-person at the Technical University of Munich main campus over several days. For complete survey responses, participants were rewarded with free coffee and cookies for competing the survey. Finally, some individuals participated online via the publicly open survey link that was distributed on media channels (e.g. via LinkedIn).

2.2.3 Sample characteristics

Total number of valid responses

The data cleaning process of the collected raw data consisted in removing respondents that (i) did not provide their consent to save the data, (ii) only previewed the survey, (iii) were missing a respondent ID, (iv) were living outside the targeted study area (based on ZIP codes), (v) did not fully complete the survey and (vi) had a response duration below four minutes, which was set as the minimum response time. Detailed information on the filtering process can be found in D4.2, Living Lab implementation report Eastern Austria (Kirchberger, et al., 2023).

This resulted in 2,515 valid responses across all study areas, with all areas meeting the target of at least 500 participants per region (Figure 2-3). The difference between the individual survey regions may lie in the different survey methods, intentional oversampling or the number of responses that had to be eliminated due to the data cleaning process. Furthermore, considering that the largest number of face-to-face events was conducted in the Dutch and Belgian living labs, the occurrence of the largest sample in this area could be attributed to the higher response quality and completeness probability of this format in comparison to panel surveys or random samples.

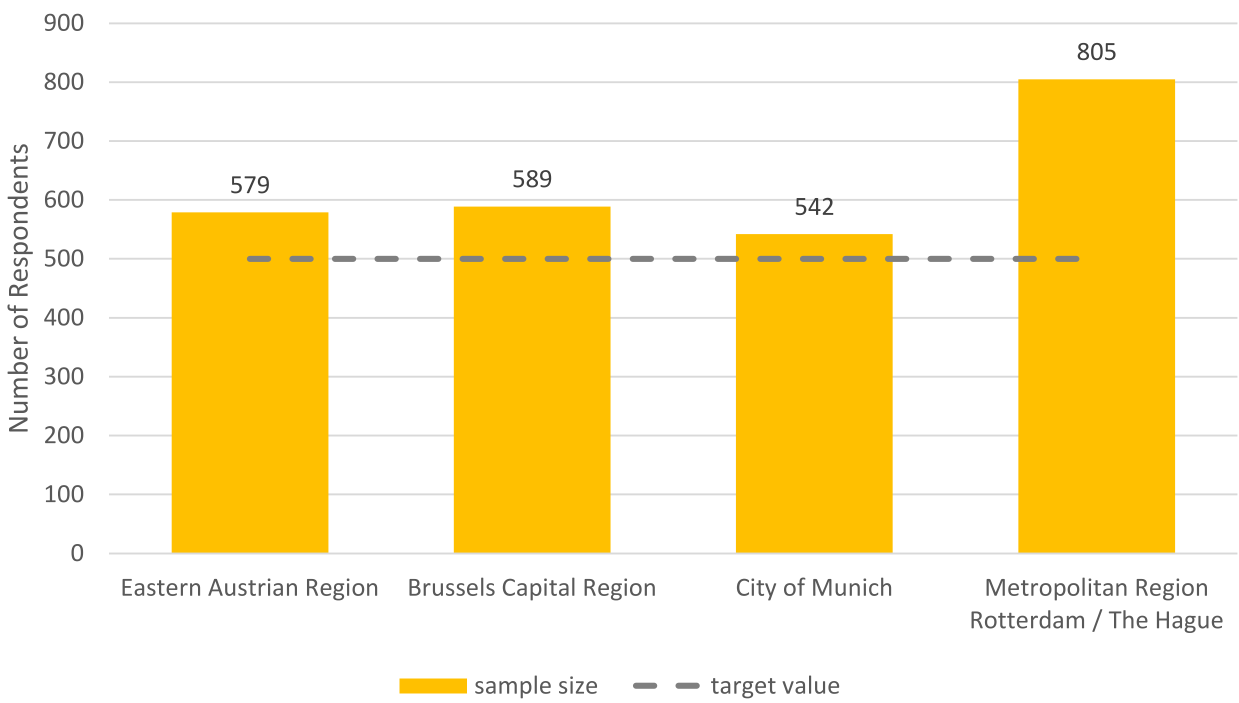


Figure 2-3. Sample size per study area

<u>Gender Distribution</u>

The distribution between male and female in total across all study areas corresponds almost to the distribution shown in the census of the total population with 51% women and 49% men, not considering very few people who stated others or did not want to answer this question (9 people in total). However, due to the aim to analyse the needs of females as one of the vulnerable to exclusion groups, the share of valid responses was slightly oversampled in the Metropolitan Region of Rotterdam - The Hague and the Eastern Austrian Region (Figure 2-4).

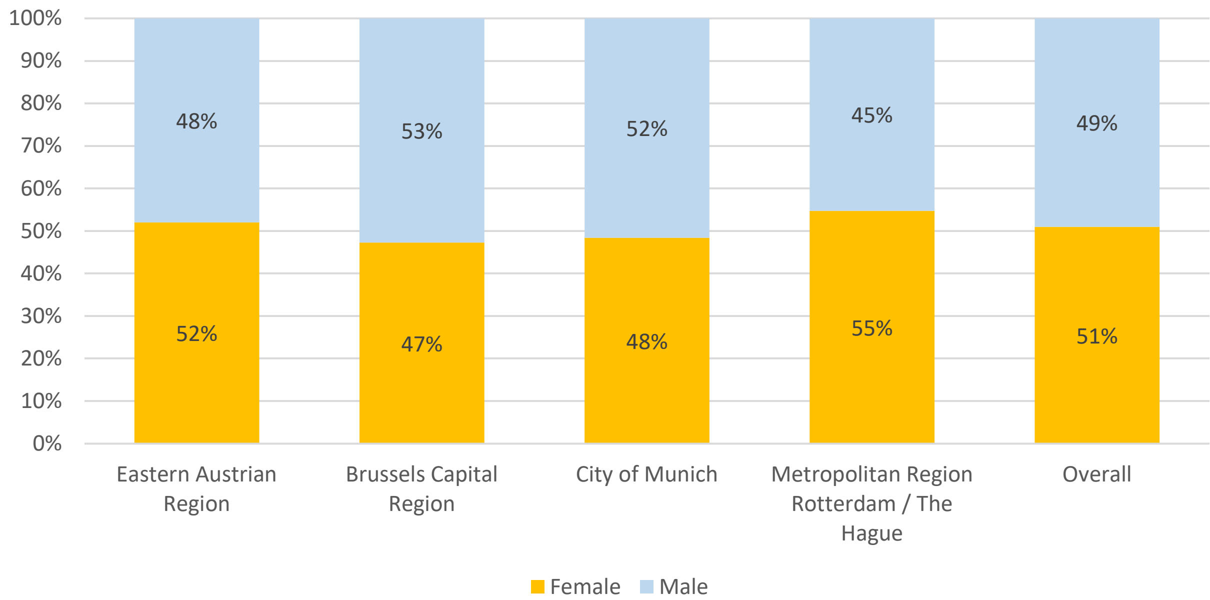


Figure 2-4. Gender distribution per study area

<u>Age Distribution</u>

One might assume that the proportion of older people among residents of rural areas is higher than in urban areas. Therefore, for the Eastern Austria study area, we distinguished between census data from the City of

Vienna and the Province of Lower Austria in order to identify if there are significant differences between these two areas. The group of older people is, on the one hand, a hard-to-reach group in surveys and, on the other hand, a vulnerable group of interest defined in the SmartHubs project. Therefore, a minimum number of people older than 65 years was required (see Table 2-2). The proportion of this group in the data set ranges from 12 to 26% and is almost in line with the census, which shows a proportion of 17% on the average over the four survey areas (reference years 2022 and 2023). However, since the location of the mobility hub in Munich, and thus the survey area, was defined as being near the Technical University, the proportion of younger participants in the survey at this location was above average with 32% younger than 25 years in the Munich sample (Figure 2-5).

Table 2-3. Share of people in the study areas according to census data per age group

	Age class				
Census Data	< 25	25 to < 45	45 to < 65	> 65	Data Source
City of Vienna	27%	30%	25%	18%	(Statistik Austria, 2023)
Lower Austria	27%	22%	30%	21%	(Land Niederösterreich, 2023)
Brussels Capital Region	31%	32%	24%	13%	
City of Munich	25%	32%	25%	18%	(Brinkhoff, 2022)
Rotterdam / The Hague	30%	30%	24%	16%	
Overall	27%	29%	26%	17%	Own calculation based on data sources mentioned above

Compared to the proportions of age groups as presented in the census data for the total population of the four study areas, the survey data show a disproportionate share of persons between 25 and 45 years of age, which is mainly caused by the fact that we did not include participants under the age of 18 in the survey causing the proportion of under 25 years to generally be lower. While the proportion in the census is about 20% on the average in the survey areas, the data set includes about 40% of this group in all study locations. However, by focusing on the group of interest as defined above, the targeted proportion of older persons in the overall data has been achieved to serve as basis for in-depth analysis (Table 2-4, Figure 2-5).

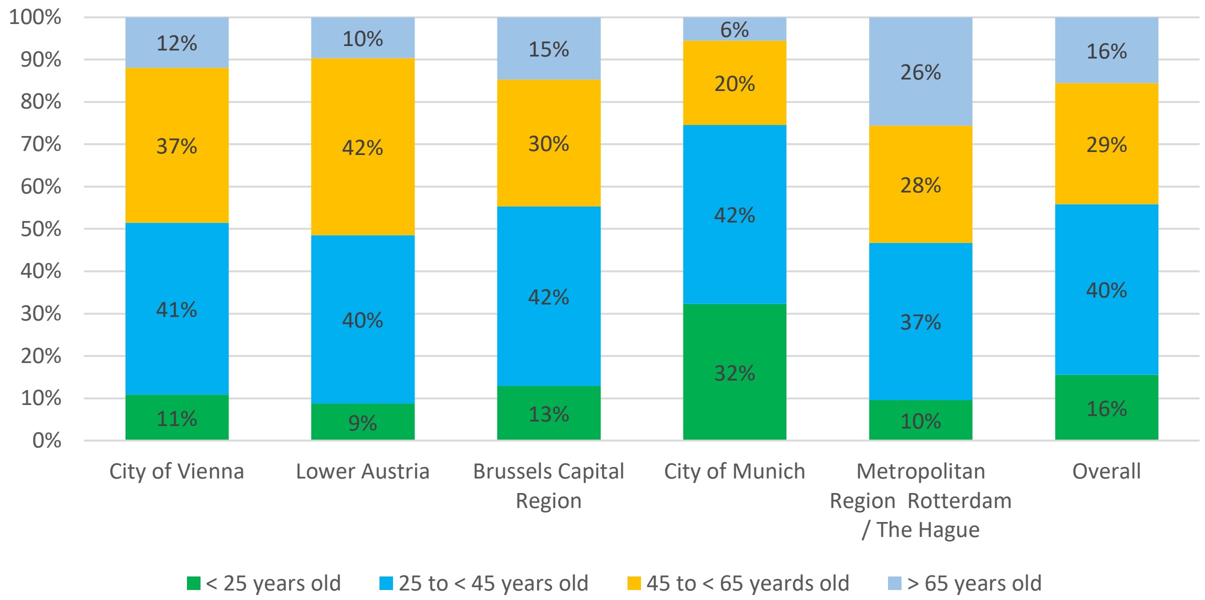


Figure 2-5. Age distribution per study area

Table 2-4. Comparison between target value and share / number of persons in the data set for older people

	Share / number of persons older than 65	
	Target value	Data set value
Austrian Eastern Region	100 respondents	12% (69 respondents)
Brussels Capital Region	~11%, min= 50 respondents	15% (87 respondents)
City of Munich	100 respondents	6% (30 respondents)
Rotterdam / The Hague	50%, min= 200 respondents	26% (206 respondents)
Overall	min 450 respondents	16% (392 respondents)

Education Level

The proportion of persons with compulsory education or less varies in the sample between 19% (Brussels Capital Region) and 37% (City of Vienna). However, in order to be able to compare the sample data correctly with the data source for the distribution of the education level among the total population, we considered only respondents older than 24 years (2.125 people). The comparison shows the planned overrepresentation of persons with compulsory education or less. The proportion of this group in the total population (25 to 65 years old) is between 12% in Munich and 23% in Rotterdam/The Hague (Table 2-5), while the share in the sample ranges between 19% and 41%, resulting in a slight variation in the other groups considered. Finally, although two study areas did not reach the predetermined quota for this group, the target of a minimum number of respondents with compulsory education or less in the data set was achieved overall (Table 2-6, Figure 2-6).

Table 2-5. Share of people in the study areas according census data of education level of people between 25 and 64 years

	Education Level			
Census Data	Compulsory education or less	Senior high school	University	Data Source
City of Vienna	15,1%	42,3%	42,7%	(Eurostat, 2023)
Brussels Capital Region	17,3%	30,4%	52,3%	
City of Munich	12,3%	40,8%	46,9%	
Rotterdam / The Hague	22,6%	37,5%	39,8%	

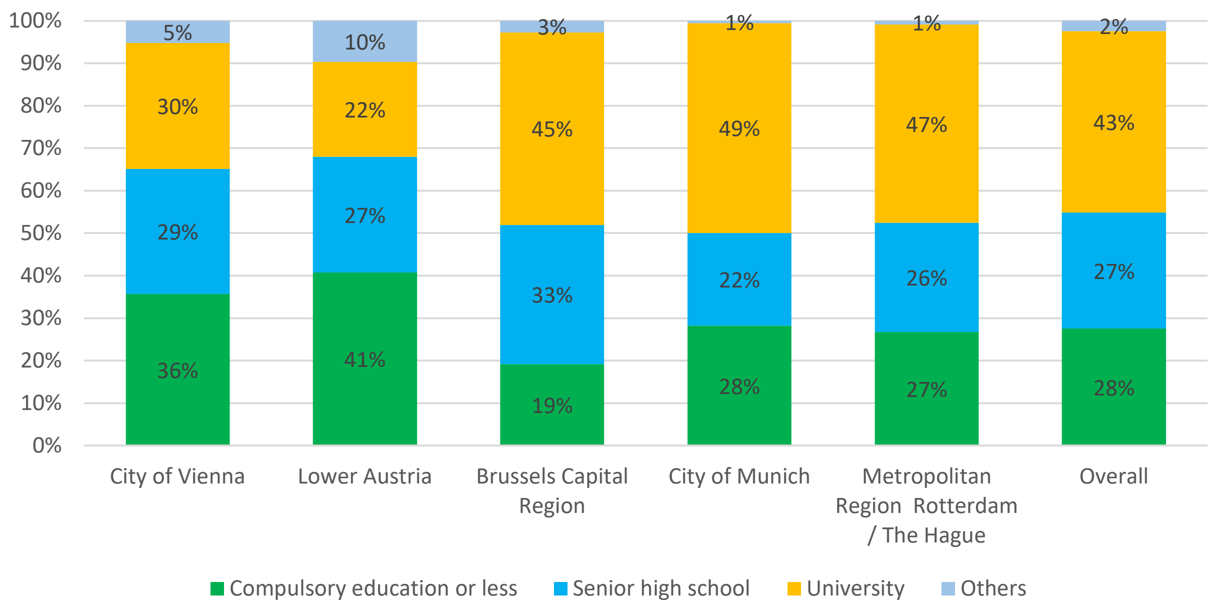


Figure 2-6. Share of education level per study area

Table 2-6. Comparison between target value and share / number of persons in the data set with compulsory education level or less

	Share / number of persons with compulsory education level or less	
	Target value	Data set value
Austrian Eastern Region	~ 4%, min 100 respondents	37%, (212 respondents)
Brussels Capital Region	7%, min 35 respondents	19%, 49 respondents
City of Munich	~ 12%, min 60 respondents	28%, (44 respondents)
Rotterdam / The Hague	~ 10%, min 50 respondents	27%, 17 respondents
Overall	min 245 respondents	322 respondents

<u>Digital Mobility Skills</u>

As mentioned in the survey description (see chapter 2.1.1), responses from two different questions are essential to derive the digital mobility skills level in regard to smartphone and apps usage. In case a respondent does not use a smartphone or only uses it for phone calls and messaging, then this person belongs to level 0 whereas a smartphone owner and user who does not exploit it for trip planning is assigned to level 1. People who plan trips via their smartphone are members of level 2. Finally, individuals who exploit all the capabilities of their smartphone regarding travelling (planning, booking, paying) have the highest digital skills at level 3 (Horjus, et al., 2022). Due to the high market penetration and the high percentage of cell phone owners of at least 80% in the four countries where the living labs are located in, people with lower digital mobility skills is a hard-to-reach group for survey participation. In total, however, the data set includes 143 respondents with lower digital skills, which is more than originally planned, with a slight shortfall in Munich compared to the planned value of 25 persons per living lab. The latter could be caused by the fact that the location of the mobility hub is close to the university and, thus, in the data collection area, younger people with advanced digital skills are present (Figure 2-7).

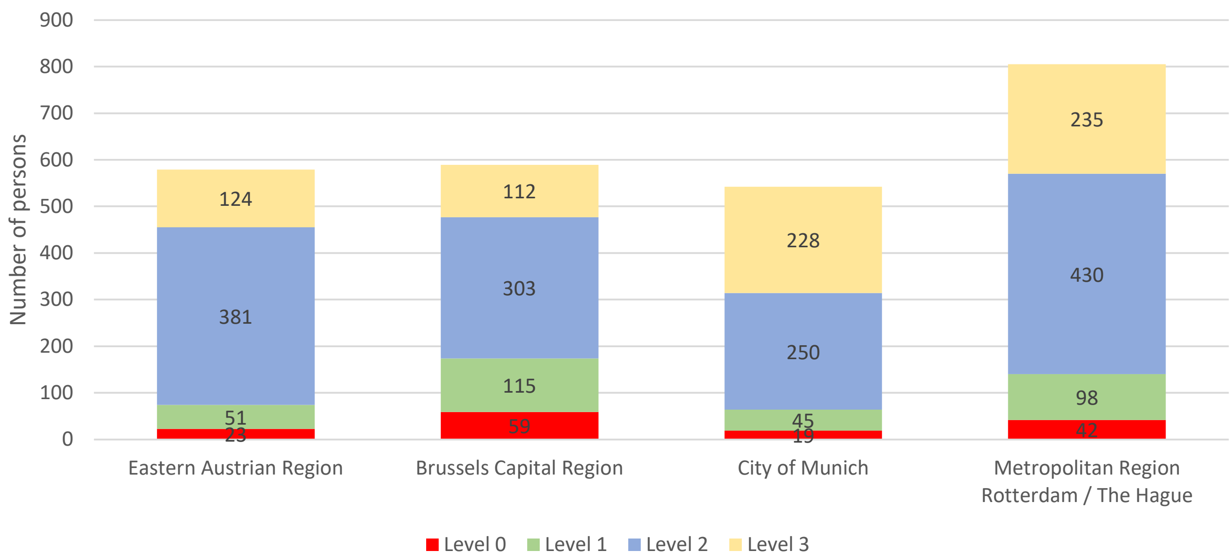


Figure 2-7. Total number of respondents per level of digital mobility skills per study area

<u>Income</u>

Mobility behaviour is not only directed by individuals' salary but also of their households' wealth. Therefore, we analyse income in the household level rather than per individual. Respondents did not have to declare their monthly salary, but were asked to estimate their income according income classes. The upper limit for the low-income household group was set at 1.600 €. The data set includes 535 people belonging to this group, almost equally distributed over the four living labs. A small deviance is noticeable in the Munich area which could be due to the age distribution of the Munich sample (see Figure 2-5). Eastern Austria and Munich hit the target values as planned, but Metropolitan Region of Brussel and Rotterdam/The Hague were not fully able to reach 200 persons (Figure 2-8).

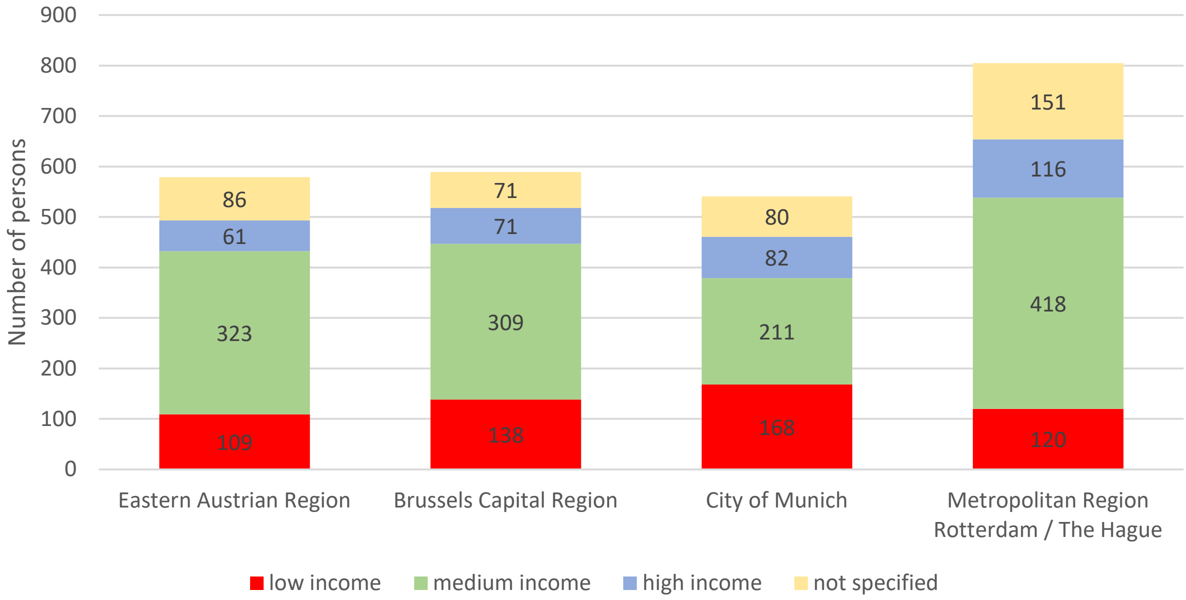


Figure 2-8. Total number of respondents according income class per study area

Table 2-7. Comparison between target value and share / number of persons in the data set with less income

	Share / number of persons with less income	
	Target value	Data set value
Brussels Capital Region	50%, min= 200 respondents	23% (138 respondents)
City of Munich	100 respondents	31% (168 respondents)
Austrian Eastern Region	20%, min= 100 respondents	19% (109 respondents)
Rotterdam / The Hague	50%, min= 200 respondents	15% (120 respondents)
Overall	min 600 respondents	535 respondents

Children per household

Travelling with children might be an issue when considering the use of a mobility hub, in particular the use of a shared micromobility, so the proportion of households with and without children could influence the impact of mobility hubs. The proportion of households without children in the sample ranges from 64% (Brussels Capital Region) to 78% in the Metropolitan Region Rotterdam/The Hague, which results in a proportion of 73% overall across all study areas (Figure 2-9). These percentages are lower than in the census data of the four respective countries in which they vary between 74% (Belgium) and 80% (Germany). Although this overrepresentation of households with children could affect the analysis findings, it also ensures that we can investigate in-depth the needs and barrier of persons with children in terms of the use of mobility stations.

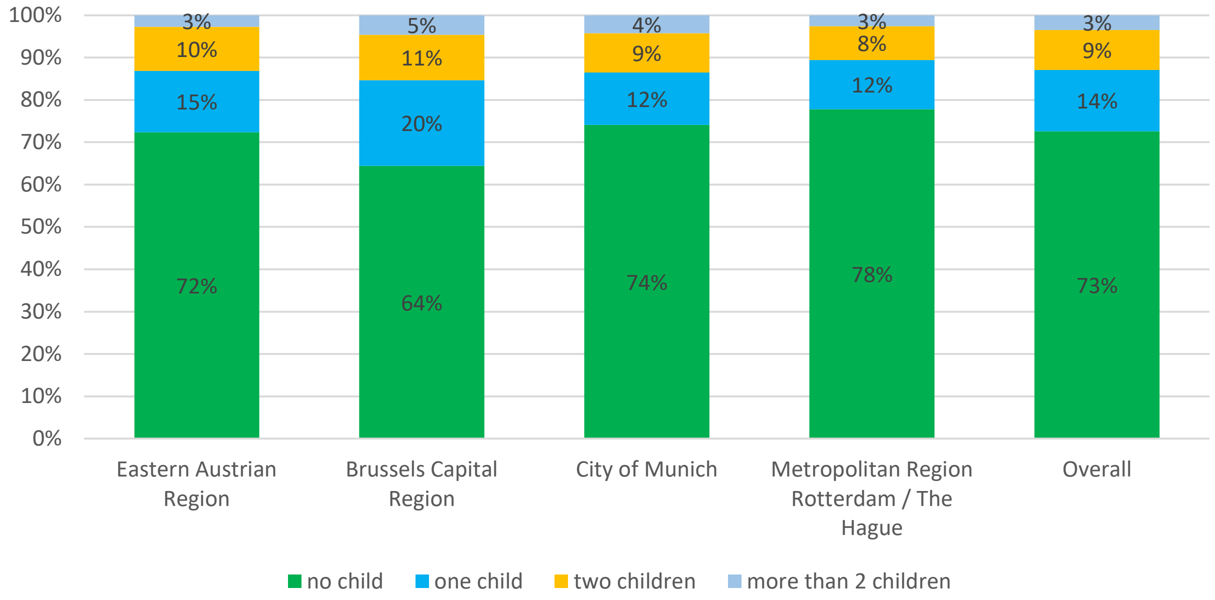


Figure 2-9. Share of number of children per household per study area

<u>Car ownership</u>

Based on the characteristics of the survey panel in the Brussels Capital Region and Munich study areas, 43% of respondents do not have access to a car (Figure 2-10). In contrast, in the Eastern Austria study area, only 29% of respondents are "car-free". The latter could be explained by the car-dependency in rural areas, such as those of the Lower Austria study region. The total share of car-free people is 36% (908 respondents), but only 19% of the respondents are not owning a driving license, neither for car or motorcycle. The car ownership rate in the data set (about 795 cars per 1000 inhabitants across all living labs) differs and is higher than the census (between 572 in Austria and 628 in Germany). However, this is a good basis to analyse the travel behaviour of currently car-oriented people and estimate the changes that mobility hubs could bring to their behaviour, and consequently to private car usage and ownership.

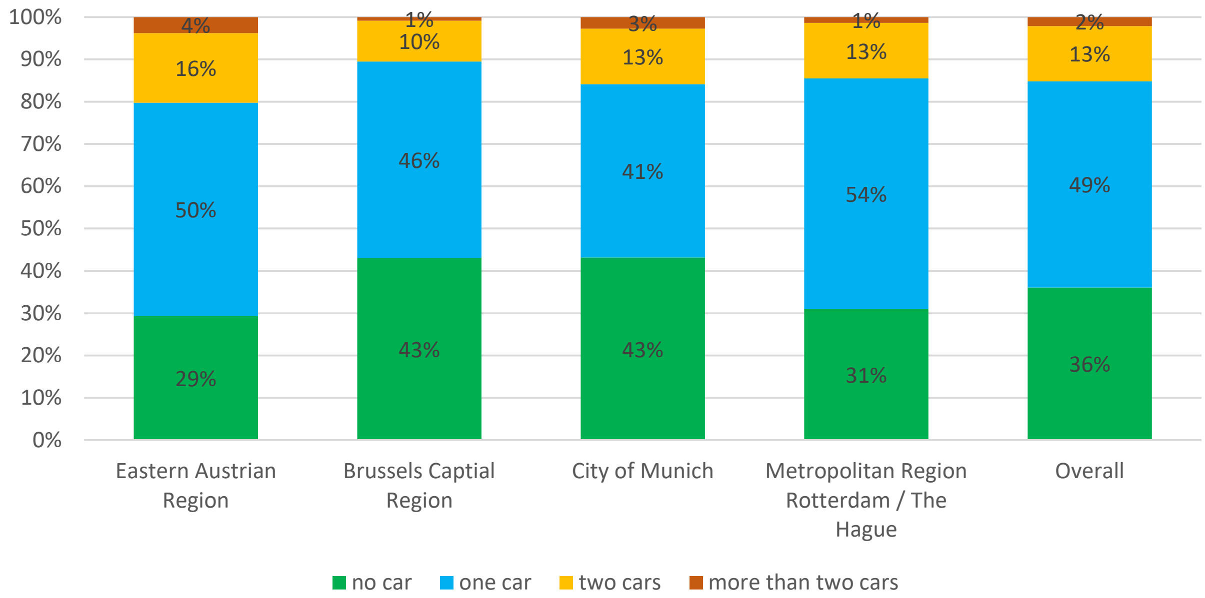


Figure 2-10. Share of number of cars per household per study area

Availability of vehicles per household

In order to obtain a complete picture of the availability of vehicles per household to which the respondents belong, we analysed the proportion of privately-owned vehicles in the data set (multiple answers possible). 64% of the respondents in all study areas live in households where at least one bicycle is available, and in comparison, only 17% have at least one e-bike in their household. On the other hand, same percentage as with bike applies to car (Figure 2-11). Thus, the sample forms a solid basis for analysing potential shifts towards sustainable mobility due to the implementation of mobility hubs, not only among people who adopted this "lifestyle" already.

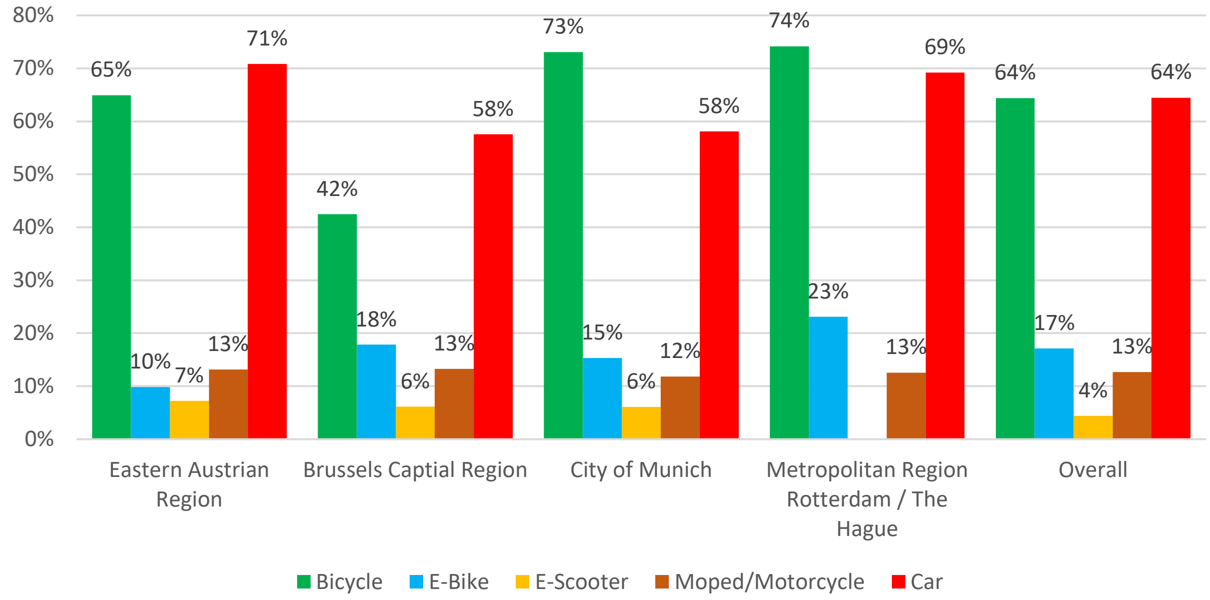


Figure 2-11. Share of private owned vehicles per household per study area

The proportion of people with bicycle in the household is at 64% in the sample, but more than 90% of the respondents stated that they are able to ride a bicycle (with the exception of the Brussels Capital Region, 79%), thus, survey data enables the analysis on identifying reasons and barriers why people are currently not using shared mode offers, in particular bicycle or e-bikes. In comparison, only half of the respondents in total stated to be able to ride an e-scooter.

This remained of the present deliverable provides insight into the analysis of the whole survey sample considering its characteristics with a focus on mobility behaviour. Further analysis on needs and preferences of vulnerable-to-exclusion population groups is available in D5.3, SmartHubs Equity Assessment (Garritsen, et al., 2023).

3 PATTERNS OF MOBILITY HUB USAGE

This chapter focuses on the investigation of the current users and use cases of mobility hubs. Since shared mobility is not only an important component of hubs but also an emerging type of mobility on which knowledge is still scarce, we first reveal the profiles of individuals who have already adopted shared mobility for their trips (section 3.1). In section 3.2, we concentrate on understanding which people are currently more and less attracted to mobility hubs and on revealing the usage patterns.

3.1 Shared mobility users

Before analysing the users of mobility hubs, as self-reported in the survey, in the present section we gain insight into how people use (or not) shared mobility. Shared mobility services are currently available in all living labs of the Smarthubs project. Some operators exclusively offer a single shared mobility scheme whereas in some cases shared mobility is provided as part of a multimodal system. In this section, we concentrate on revealing the role of shared mobility in mobility behaviour, without distinguishing between these two cases.

3.1.1 Descriptive analysis of shared mobility usage

While there are multiple shared mobility services, we focus here on four different types: shared car, shared bike, shared mopeds, and shared e-scooters. The first three services are currently available in all living labs whereas in the region of Rotterdam/The Hague shared e-scooters are illegal in public space. In Table 3-1, the proportion of users in the sample is presented. Every person who travels by a mode at least once within the last twelve months is classified as a user of this mode. In the table, the sharing modes with the highest and lowest number of users are highlighted. As seen, in the total sample, shared e-scooters are the mode which attracted the highest share of users in the last year.

The younger sample in Munich revealed the highest interest in using shared mobility. Considering bikes, e-scooters and cars, more than one third of the Munich survey participants have experiences with at least one of these modes. On the contrary, in the rural areas in Austria, users of any system are less than 11%. Users' percentage is more than double for all shared modes (except shared moped) in the City of Vienna than in the countryside, revealing a consistently reduced number of people that travel by shared modes in rural areas. Nevertheless, the patterns regarding the most and least attractive mode are similar between the urban and rural Austrian case studies. Specifically, car sharing is the most and shared e-mopeds the least attractive services in both areas. In the Metropolitan Region of Rotterdam/The Hague, approximately one fourth of the survey respondents travelled by any shared service, with e-mopeds being the most popular choice. Car and bike sharing attract less customers, at least for single usage (Table 3-1).

Table 3-1. Proportion of people with experiences in shared mobility per service type and study area

		 Shared bike	 Shared e-scooter	 Shared car	 Shared moped
Brussels Capital Region		33%	31%	33%	16%
City of Munich		33%	38%	37%	16%
Eastern Austria	City of Vienna	20%	21%	28%	6%
	Rural areas in Lower Austria	9%	7%	11%	4%
Metropolitan region Rotterdam/The Hague		17%		15%	26%
Full sample		24%	29%[1]	26%	17%

[1]Note: Excluding the respondents in the Dutch living lab. Least used mode. Most used mode.

Although Table 3-1 provides insight into the percentage of people who have used the various shared services at least once and the interest of people to familiarize with these services, it does not inform about the integration and contribution of these modes to daily mobility behaviour. To obtain this information we analyse and visualise the reported usage frequency per mode and study area (Figure 3-1 to Figure 3-4). In these figures, only data from users of each shared mode are illustrated, thus the total number of data varies per bar (see Table 3-1 for the percentage of users per service and study area).

In Eastern Austria, in total 142 people include car sharing in their chosen modes. Thus, the distribution of usage frequency shows that 70% (N~100) of these users travel by shared car a few times per year. Despite the small modal split of shared mopeds in Eastern Austria (~5%, see Table 3-1), one third of their users travel at least weekly by this mode, indicating the integration of shared mopeds in their daily mobility. While e-scooter attracted more occasional users, in Eastern Austria the usage intensity of bike sharing is stronger than that of e-scooter sharing (Figure 3-1) among existing users.

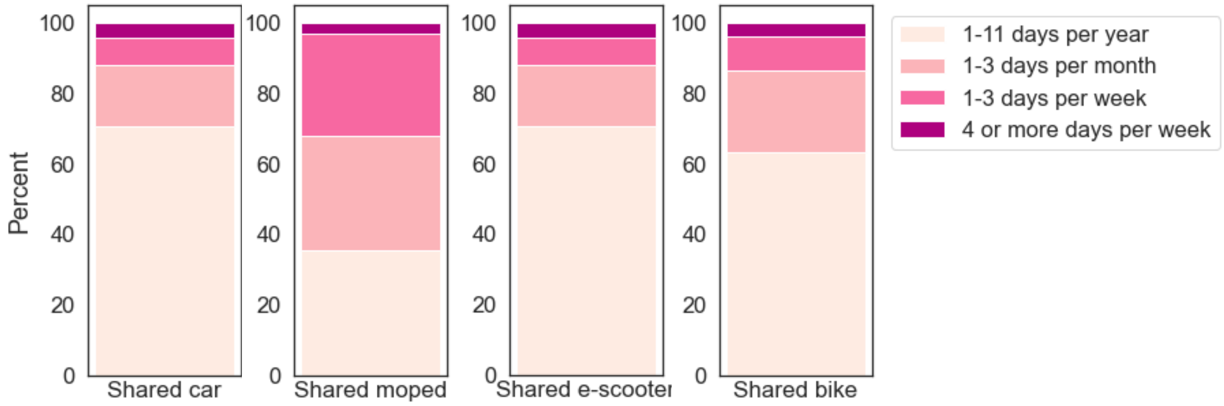


Figure 3-1. Shared mobility services usage frequency in Eastern Austria (users only)

In Munich, the distribution of the usage frequency does not vary significantly between the three shared micromobility modes (e-scooter, moped, bicycle) with around half of their users travelling by them at least once a month. On the contrary, although the users/non-users distinction revealed almost equal number of users of e-scooter and car sharing (see Table 3-1), but a less number of trips are made by shared car (Figure 3-2).

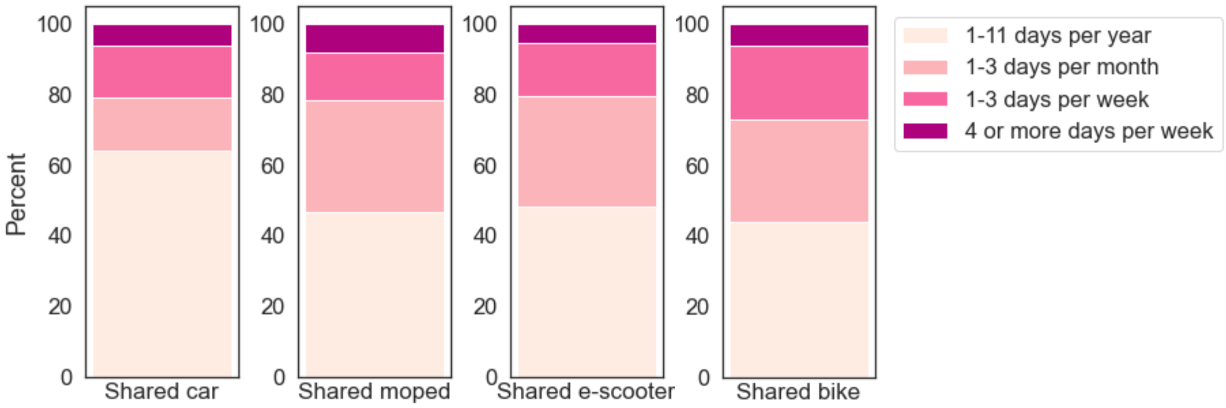


Figure 3-2. Shared mobility services usage frequency in Munich (users only)

Table 3-1 shows that among all study areas, the highest share of bike and car users is found in the Brussels Capital Region sample. Moreover, current users of all services, also tend to travel more frequently in Brussels Capital Region than in any other study area. Around 15%-20% of the users of each system travel by these modes four or more days per week. Although the usage intensity distribution is similar across the different modes, car sharing appears the largest proportion (41%) of weekly or more frequently travellers (Figure 3-3).

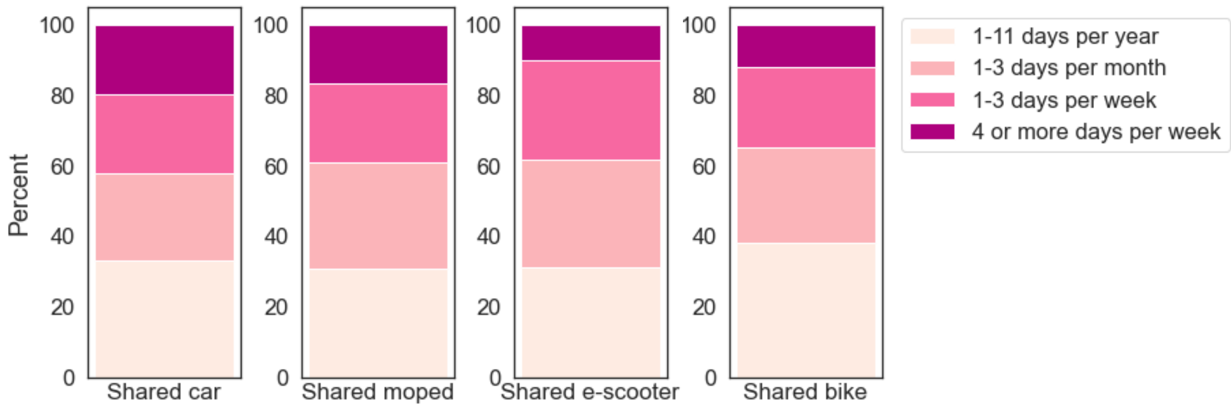


Figure 3-3. Shared mobility services usage frequency in the Brussels Capital Region (users only)

Similar to the findings of the Belgian sample, car sharing users appear to be the most active users in the Rotterdam-The Hague study area. Nevertheless, the Dutch sample analysis reveals that the share of frequent users is around half of the one in the Belgian dataset, across all shared mobility services. In addition, considering both the user ratio (Table 3-1) and the usage frequency distribution, we can conclude that in the Dutch sample, bike sharing is the most underused shared mobility service (Figure 3-4). Considering the local and sample characteristics these findings could be due to the high share of own bike possession and usage.

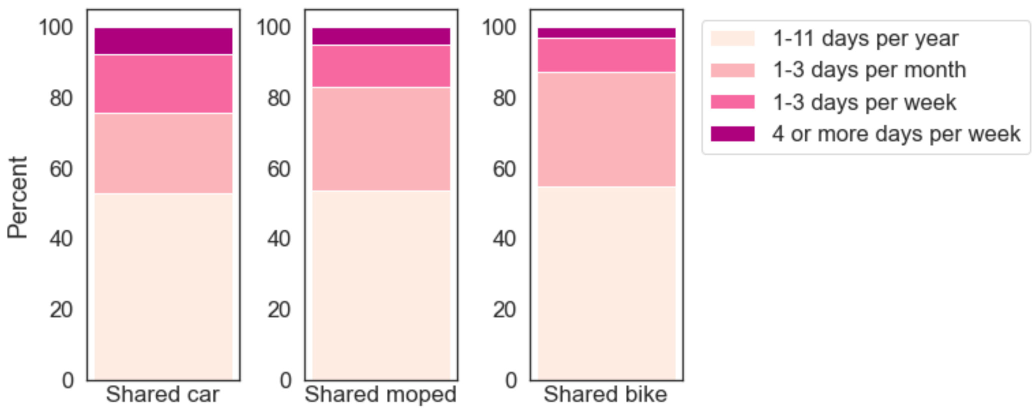


Figure 3-4. Shared mobility services usage frequency in Rotterdam/The Hague (users only)

3.1.2 Profiles of shared mobility users

Based on the above-mentioned usage frequency of shared modes, as well as the degree of travelling by public transport, own modes and on foot, we identify population clusters which present similar mobility profiles. For the three study areas with the same modes available in their shared mobility offers (Vienna, Brussels Capital Region, and Munich), we combine the data to reveal the most dominant user profile across different European urban areas. We then test how the distribution and characteristics of these profiles vary across the three cities. Considering the absence of shared e-scooters in the Dutch living lab, we perform a separate analysis for its data.

Based on three arguments we decided to exclude the rural areas of Lower Austria from the analysis. Firstly, shared mobility is more recent and scarce (e.g. still no e-scooter sharing operation) in these areas and, as such, we do not expect a well-established user profile. Secondly, by restricting the analysis to the comparison among different urban areas we can test whether we can claim that there is a unique shared mobility user profile in the European context or not. Finally, the sample size of the rural areas is not sufficient to conduct a separate analysis on the rural shared mobility user profile.

To reveal the profile of shared mobility- and thus, mobility hubs- users we conducted a Latent Class Analysis (LCA). LCA allows clustering a population into homogenous groups based on their characteristics. In our case, the considered characteristics are the degree of travelling by various shared mobility offers. One of the core advantages of LCA for our analysis is that it does not necessitate a prior definition of the number of groups. Since it was unknown how many different profiles we targeted, the LCA allowed for stepwise increase in the considered profiles until the model does not improve further both either statistically or conceptually.

The LCA model has two subcomponents: the measurement and the membership model. Considering that the survey provided information on individuals' mobility and sociodemographic characteristics, we involved both types in the definition of the profiles. Nevertheless, each group of characteristics was exploited in a different part of the model. On the one hand, mobility information, and in particular, travel frequency by different own and shared modes, was the input for the measurement model of the LCA. On the other hand, individual characteristics, such as age, gender, and digital mobility skills, were included in the membership model (Figure 3-5). As mentioned above, for the LCA estimation, data from three study areas were combined. To examine the variance across these areas, the respondents' origin area (see "Living lab" in Figure 3-5) was added as an inactive variable in the membership model. In the LCA on the data from the Rotterdam/The Hague area, the "Shared e-scooter usage frequency" is substituted by the "Shared (e-) moped usage frequency" (Figure 3-6).

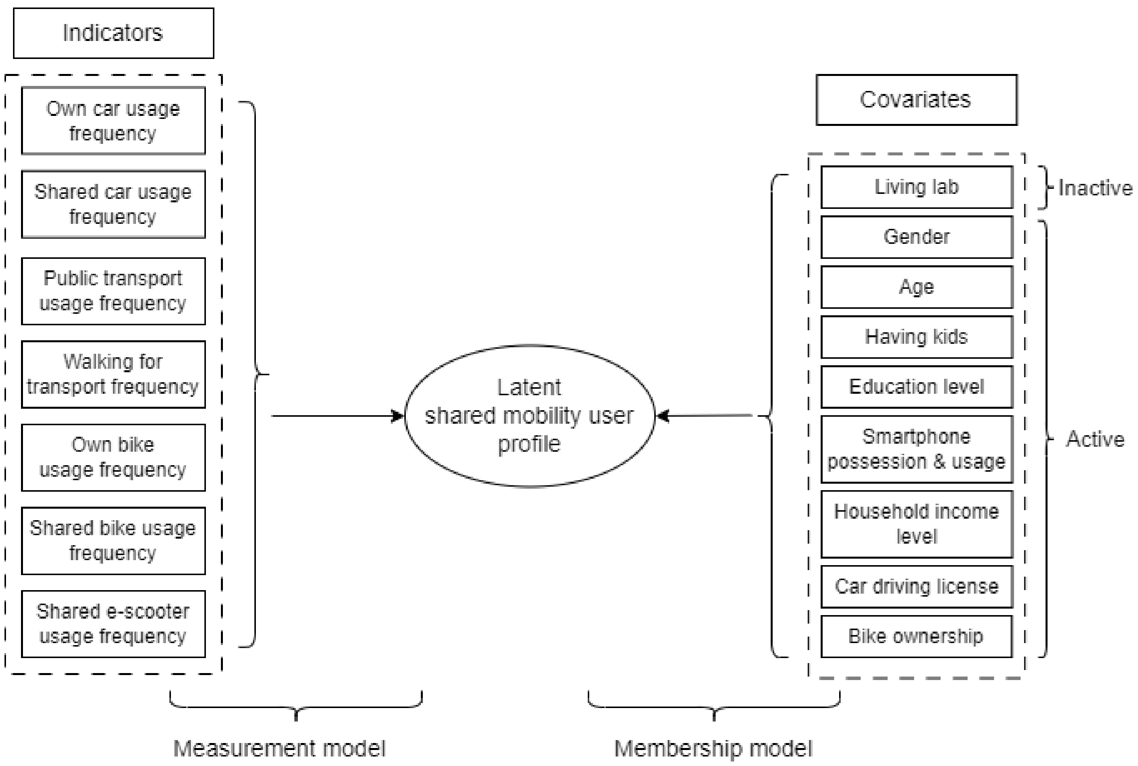


Figure 3-5. Latent class analysis conceptual design (Munich, Brussels Capital Region, Vienna living labs)

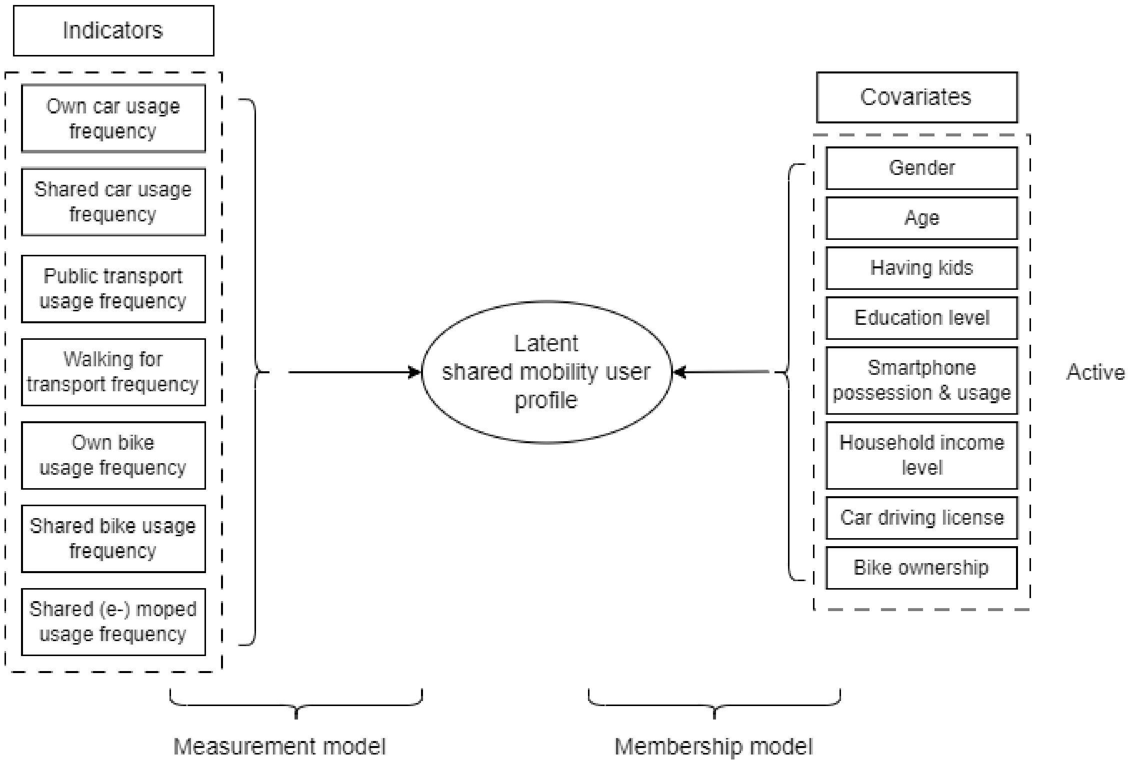


Figure 3-6. Latent class analysis conceptual design (Rotterdam/The Hague living lab)

For both model designs, the model estimation revealed three distinct classes. The three groups vary in terms of their preferred transport modes and their usage frequency. Although the three classes are similar across the various study areas, the model has highlighted the existence of significant differences. Profile 2 is the one representing the main users of shared mobility whereas non-users of shared mobility are distributed between the other two groups. (Figure 3-7 and Figure 3-8).

Profile 1: "*Travellers by public transport and own active modes*"
People belonging to the first class (Profile 1) are mainly public transport travellers who also very often walk and travel by their own bike to satisfy their travel needs. In the cities of Munich, Vienna and Brussels Capital Region, 25% of individuals belonging to this group cycle multiple times per week by their own bike whereas the percentage is double in the Dutch sample. On the contrary, frequent public transport travellers are less present in the Profile 1 of the Dutch sample. Although car usage is very limited for members of this class in all areas, around 30% of people living in the three cities drives their private car monthly or weekly (Figure 3-7). The share is different for Profile 1 members who live in the area of Rotterdam/The Hague, where more than 90% never drives a private car (Figure 3-8). Regarding shared mobility, while around 30% of the people in this group have been exposed to the various shared mobility services across all living labs, none of them is a frequent user. Considering all these findings we name this class "Travellers by public transport and own active modes".

Profile 2: "*Mobility chameleons*"
This class entails the most shared mobility users. The share of frequent travellers is similar across the three shared mobility offers (bike, car, and e-scooter/moped sharing). Overall, in all study areas this profile uncovers that individuals who have embraced shared mobility in their daily life, still depend a lot on travelling by other modes of transport. Travel frequency by own car is much higher than in the first class (Figure 3-7 and Figure 3-8). Moreover, the shared mobility users also travel a lot by public transport. More specifically, almost three out of four travel by public transport every week. Walking for travel is also popular for this population cluster. Based on the characteristics of this mobility profile we can conclude that shared mobility users could be characterised as "mobility chameleons". They show high flexibility in the modes they choose to travel by and they also mix different modes to conduct their trips.

Profile 3: "*Own mobility dependent*"

Contrary to the other two clusters, people in the last group appear to have less variety in their mobility profile. All members depend significantly on their private car to satisfy their travel needs. Although many of them choose public transport for some of their trips, the share of frequent public transport travellers is the lowest across the three groups. This also holds for the frequency of walking. Most people in this class accept cycling as a transport mode. However, the comparison of Figure 3-7 and Figure 3-8 reveals that cycling by own bike is more popular in the area of Rotterdam/The Hague than in the other cities. Regarding their familiarity with shared mobility, the vast majority of people in this group (>75%) has never used any shared system. Considering all values, we name the group with this mobility profile as "Own mobility dependent".

The two models reveal different distribution of the population among the three classes. In the Brussels-Vienna-Munich dataset, the first profile entails most observations whereas the model assigned most people in the Rotterdam/The Hague area to the last, car-dependent profile (Figure 3-7 and Figure 3-8). Despite this difference, in both study areas, the "mobility chameleons" group has the smallest size, with less than one fourth of the population.

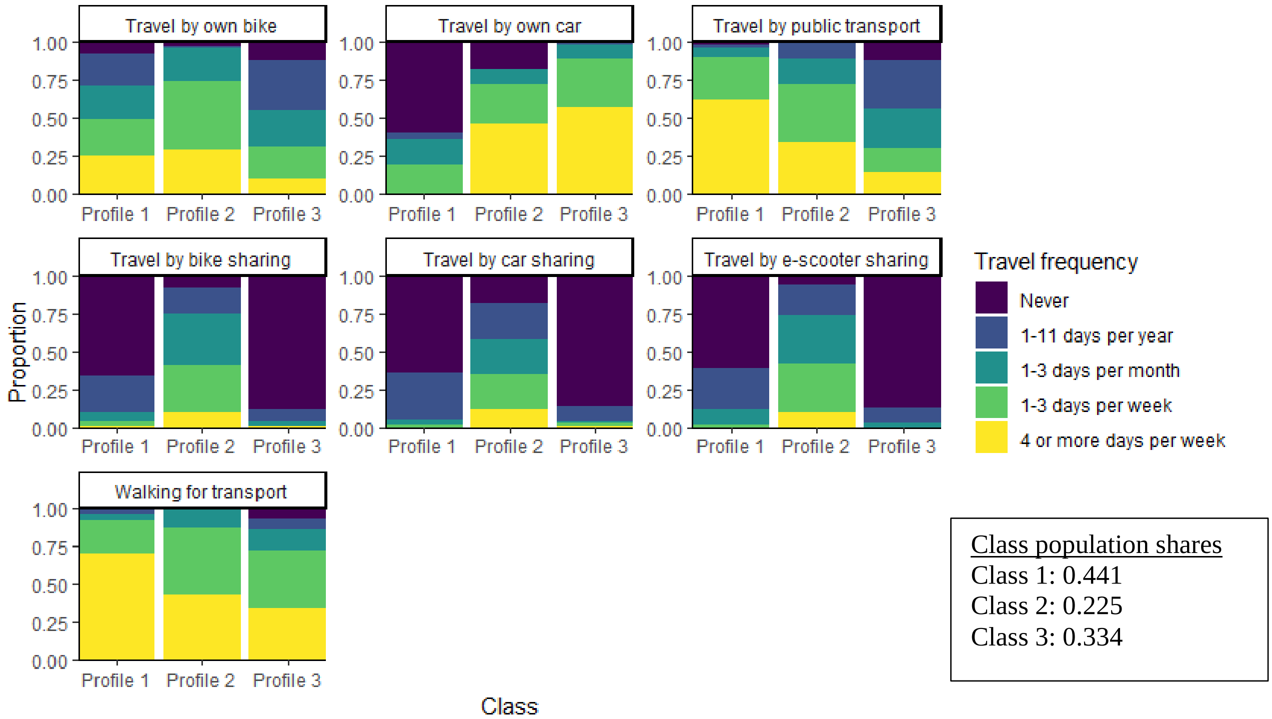


Figure 3-7. Three different mobility profiles based on mode usage frequency (Munich, Brussels Capital Region, Vienna)

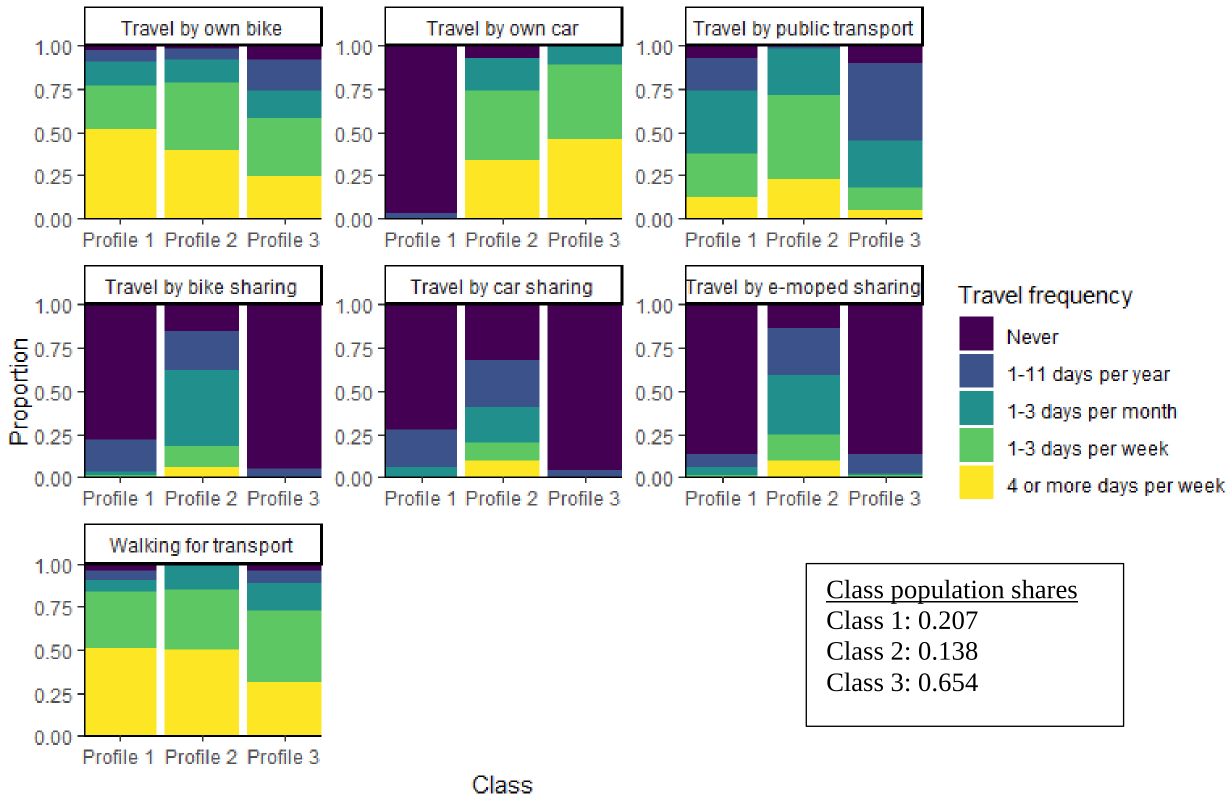


Figure 3-8. Three different mobility profiles based on mode usage frequency (Rotterdam/The Hague)

The above findings reveal the mobility characteristics of shared mobility users. The estimation of the second component of the LCA model, the membership model, provides insight into the sociodemographic characteristics of the people belonging to each group. The coefficients values were estimated in relation to membership in Profile 1. Thus, the coefficients declare a likelihood of belonging to Class 2 and 3 in comparison to being part of Class 1 (Table 3-2 and Table 3-3). Although this aspect of the membership model does not allow for a direct prediction and comparison of the probability of people with each sociodemographic characteristic to belong to each of the three classes, it provides useful information on how people who are either “mobility chameleons” or “own mobility dependent” differ from typical public transport travellers.

Focusing on the membership results for Class 2, the two models diverge regarding their significant parameters. Despite this, all but two parameters that are significant in both models also have a consistent positive or negative. For instance, people with a higher income have a higher probability of having a great variety in their mobility profile than those with low income. The same effect holds for the household synthesis. Both models suggest that people with 1 or 2 kids are more likely to be “mobility chameleons” than depend only on public transport. The latter could be due to parents’ multiple and complex travel needs which require higher flexibility. Nevertheless, the effect is reverse for parents with more than two kids in Rotterdam/The Hague.

The most noticeable disparity between the two models is the “digital mobility skills effect”. On the one hand, the combined model in the three living labs reveals that people who do not possess a smartphone are less likely to be “mobility chameleons”. On the other hand, the model estimated on the Dutch living lab suggests an increased participation of non-smartphone holders in this class. These findings could be explained by the characteristics of the local shared services in each region. In the Rotterdam/The Hague, multiple offers, including public transport and the most popular bike sharing system (OV-fiets) are available via a single card (OV-Chipcard) and access to them does not require the usage of apps (Rijkswaterstaat Environment, 2023). In the cities of Munich and Vienna and the Brussels Capital Region, shared mobility is offered exclusively via apps, so it is impossible for non-smartphone users to access them.

Table 3-2. LCA membership model (Brussels Capital Region, Munich, Vienna)

Active covariates	Reference level	Levels	Coefficient Class 2 (22%)	Coefficient Class 3 (33%)
Intercept			-13.40*	-2.58
Gender	Male	Female	-0.46	0.77*
Age group	Teenagers	Young adults	-0.61	-1.38
		Adult	-1.26	-0.51
		Older	-2.09	0.45
Education level	Compulsory education	High school	-0.12	-0.99*
		Undergraduate university degree	0.01	-2.15*
		Secondary university degree	-0.51	-1.81*
Smartphone usage	No smartphone possession	Possession, but not using internet/apps	12.21*	0.24
		Possession and full usage	10.95*	-0.23
Household income	Low income	Medium income	1.12*	1.47*
		High income	1.56*	1.94*
		Elite income	1.34**	1.17*
Household synthesis	Only adults	With 1 kid	2.31*	1.36*
		With 2 kids	3.34*	2.02*
		With more than 2 kids	2.01*	0.49
Car driving	No driving ability	Active driving license	2.31*	3.31*
Bike ownership	No bike available	Owing a bike	-0.80	-0.44

*Significant at 95% confidence interval

Table 3-3. LCA membership model (Rotterdam/The Hague)

Active covariates	Reference level	Levels	Coefficient Class 2 (14%)	Coefficient Class 3 (65%)
Intercept			-24.5*	-22.18*
Gender	Male	Female	18.47*	18.27*
Age group	Teenagers	Young adult	1.73*	1.42*
		Adult	-8.73*	-7.83*
		Older	-17.52*	-15.77*
Education level	Compulsory education	High school	-0.78*	-9.01*
		Undergraduate university degree	-16.67*	-25.84*
		Secondary university degree	-33.49*	-43.06*
Smartphone usage	No smartphone possession	Possession, but not using internet/apps	-8.26*	-13.14*
		Possession and full usage	-30.58*	-44.23*
Household income	Low income	Medium income	35.18*	34.90*
		High income	69.41*	70.34*
		Elite income	36.49*	36.45*
Household synthesis	Only adults	With 1 kid	10.66*	9.61*
		With 2 kids	2.83*	2.53*
		With more than 2 kids	-17.97*	-4.84*
Car ownership	No car available	Owning a car	80.14*	101.47*
Bike ownership	No bike available	Owing a bike	-9.43*	-9.37*

*Significant at 95% confidence interval, ** Significant at 90% confidence interval

3.2 Current mobility hubs usage patterns

After revealing the mobility and sociodemographic characteristics of shared mobility users, we now investigate the level of familiarity with hubs and the main existing usage patterns. Moreover, in section 3.2.2 we conduct a descriptive analysis on the transport modes that mobility hubs replace.

3.2.1 Mobility hubs current awareness and usage

The first step towards understanding the impact of existing mobility hubs is the recognition of the level of awareness and usage of these hubs. Based on the survey data, more than half of the respondents (~ 55%) are aware of the existence of mobility hubs in their city. Males and females are similarly aware of hubs. It should be noted that due to the limited availability of data on people who identify neither as male nor female is very limited, this category is not analysed separately (Figure 3-9).

Despite the current spread of mobility hubs and the large amount of people admitting that they encounter hubs during their daily trips, less than one third of them have already become users of mobility hubs. A noticeable discrepancy is pointed between males and females, with a higher percentage of the former being users of mobility hubs (Figure 3-10).

Interestingly, it is observable that a proportion of the sample faced difficulty in making a clear statement towards their familiarity with hubs and answered "I am not sure". This response was also given to the usage question by around 10% of the participants. Considering that in the beginning of the survey a description of neighbourhood-level mobility hubs and local examples was provided, this finding reveals a remaining confusion of a population minority towards what exactly are mobility hubs (Figure 3-9 and Figure 3-10).

Further details on the comparison between multiple sociodemographic groups regarding their familiarity with hubs are available in the Smarthubs D5.3 (Garritsen, et al., 2023).

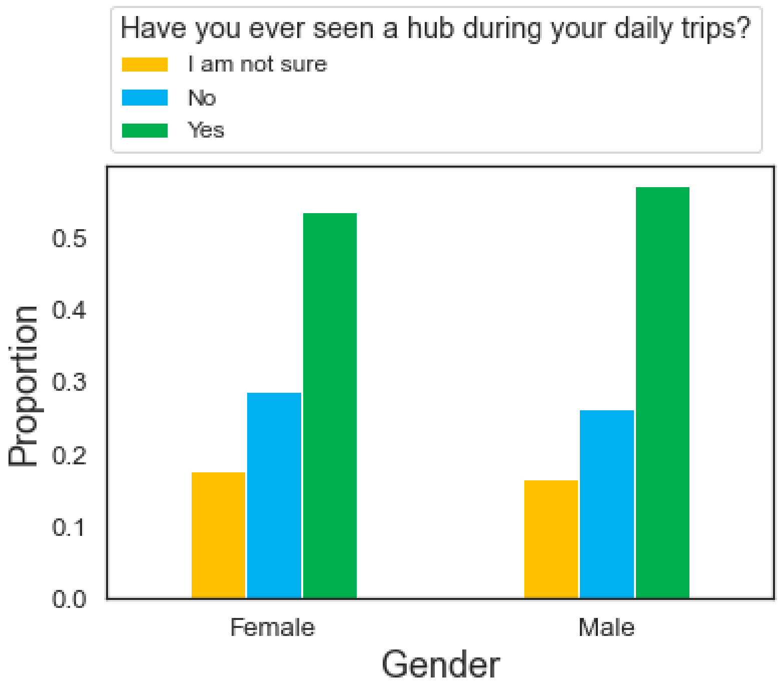


Figure 3-9. Awareness of hubs per gender

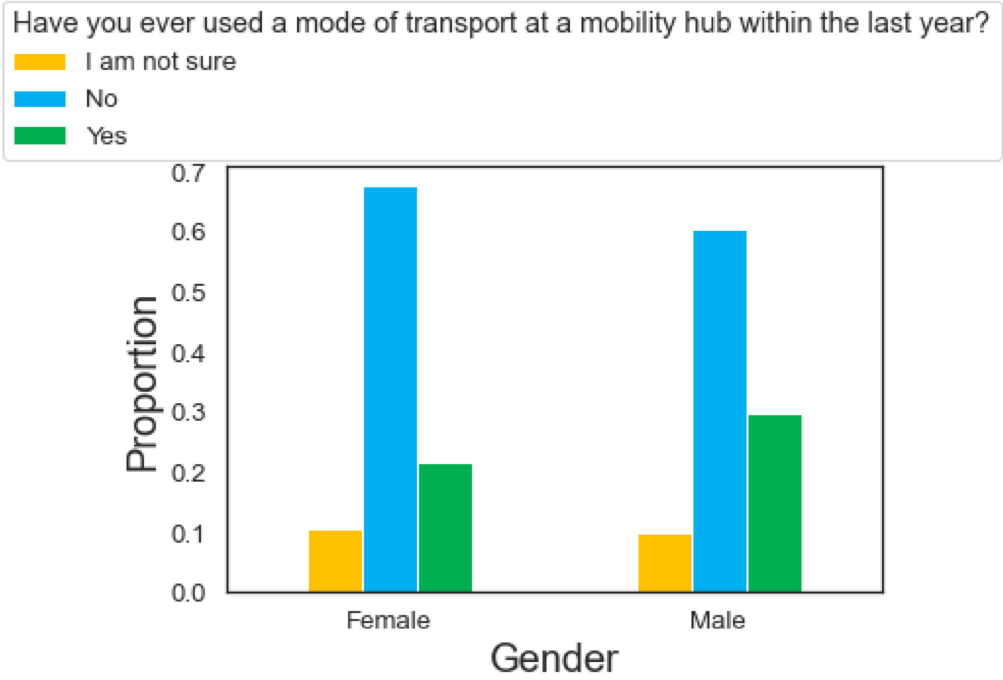


Figure 3-10. Usage of hubs per gender

In the survey, users of mobility hubs reported their latest trip. The question allowed for reporting both unimodal and multimodal trips. In Figure 3-11, we illustrate the modes used in the hub-based trips that the survey respondents described. For the visualisation of trips, we excluded reported trips that did not entail any hub-based mode at any trip stage. We also filtered the reported modes for inconsistencies such as in availability of own modes and for omitted trip links in between reported trip staged. We also do not visualise transfers between public transport modes. Therefore a chain of public transport trip links is presented as single public transport mode. For higher readability of the figure, we also do not visualise walking as a separate transfer or last mile mode. In Figure 3-11, different line widths and colours are used to highlight features of the reported trips (See Figure 3-11 legend). Bold lines indicate the most frequent trip chain(s) per first mode. In case the trip was conducted a single hub-related mode, the bold line is pink.

The vast majority of the trips using hubs started by own car, public transport, or walking. For these three initial modes, complex trips with multiple trip stages were reported. As seen in Figure 3-11, shared modes and public transport are found in various trips stages. Moreover, shared modes are also often used as access or egress modes to or from public transport, respectively (cyan and dark blue arrows).

For trips that start by shared modes, the trip chains are overall shorter and involve fewer transfers between different means of transport. Especially for trips originating by car and bike sharing, the largest proportion is unimodal trips (pink arrows). On the contrary, while some individuals reported trips exclusively by e-scooter sharing, the majority of trips that started by e-scooter continued with a public transport stage. Overall, the trips conducted by the survey respondents revealed that public transport has the highest usage frequency among all mobility hub services both as a stand-alone and as part of multimodal trips.

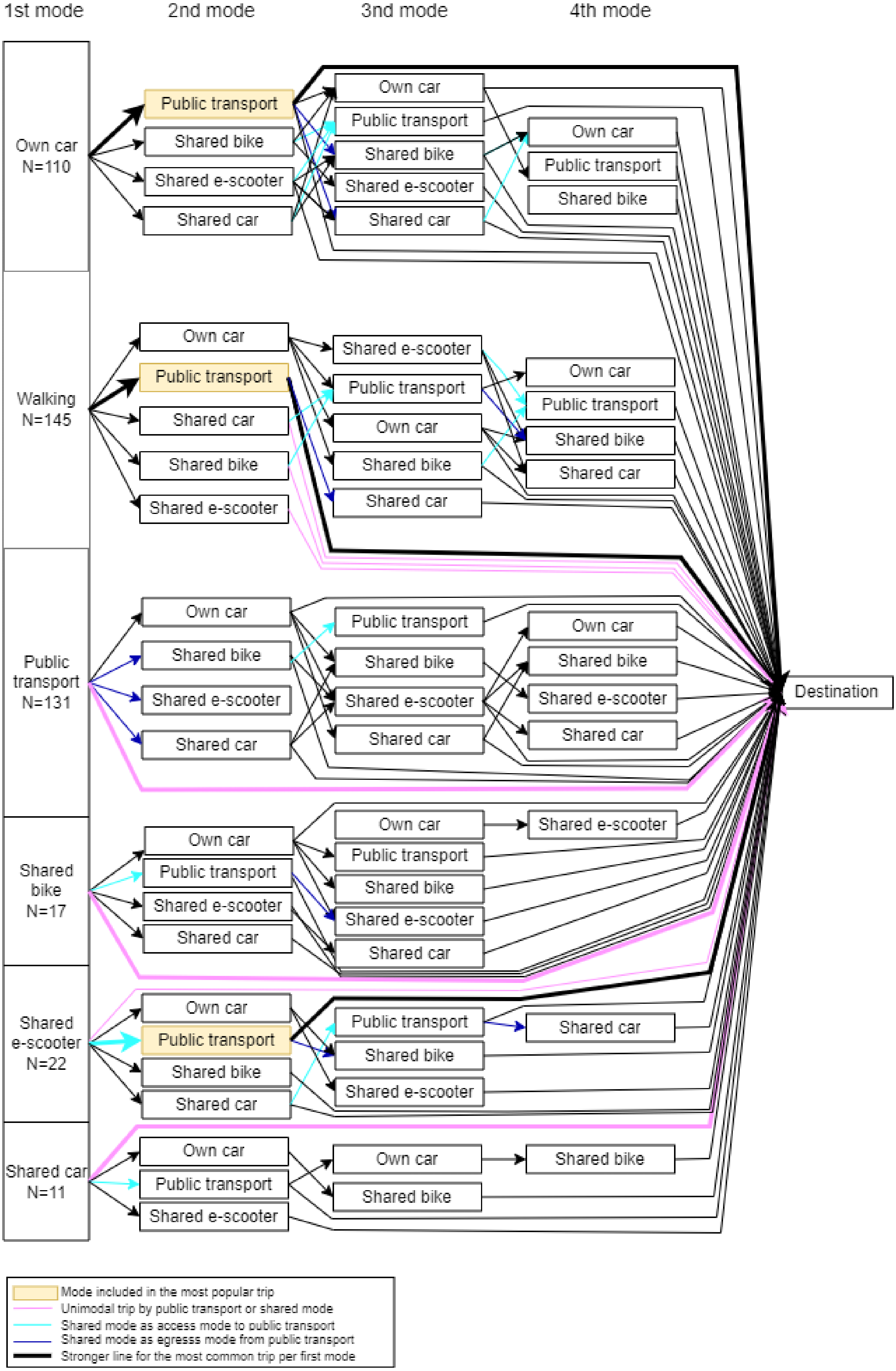


Figure 3-11. Reported hub-based trips

3.2.2 Mode substitution patterns

For the hub-related trips discussed in the previous section, the survey prompted participants to think of how they would have travelled in case mobility hubs and, more specifically, their shared mobility services were not in operation. Specifically, the question was posed as "In case that the shared modes were not available for your latest trip, which mode(s) could you have used alternatively to conduct the trip? Select all that apply". The respondents could select any own mode, public transport and walking. In addition, they had the option of stating that they could not have conducted this trip. In total, only 10 out of 402 respondents of this questions said that their trip would have been impossible in case shared mobility services were not present.

Figure 3-12 illustrates the alternative modes of the participants who would have still conducted their trip. The figure presents the results of all possible answer combinations. Public transport was the most frequently mentioned mode (N=262, 65%), with around one fifth (N=86) of the respondents indicating their only alternative to conduct their trip would have been public transport. Nevertheless, most people provided multiple alternative modes for their trip. As seen in Figure 3-12, many trips could be done by active modes, mainly on foot (50%) but also by bike (26%). Only one trip would have been conducted only by own scooter, which could be attributed to the decreased scooter ownership rate of the sample. In total, in case shared modes were not present, almost one third of the trips (N=127, 32%) could be conducted by private car.

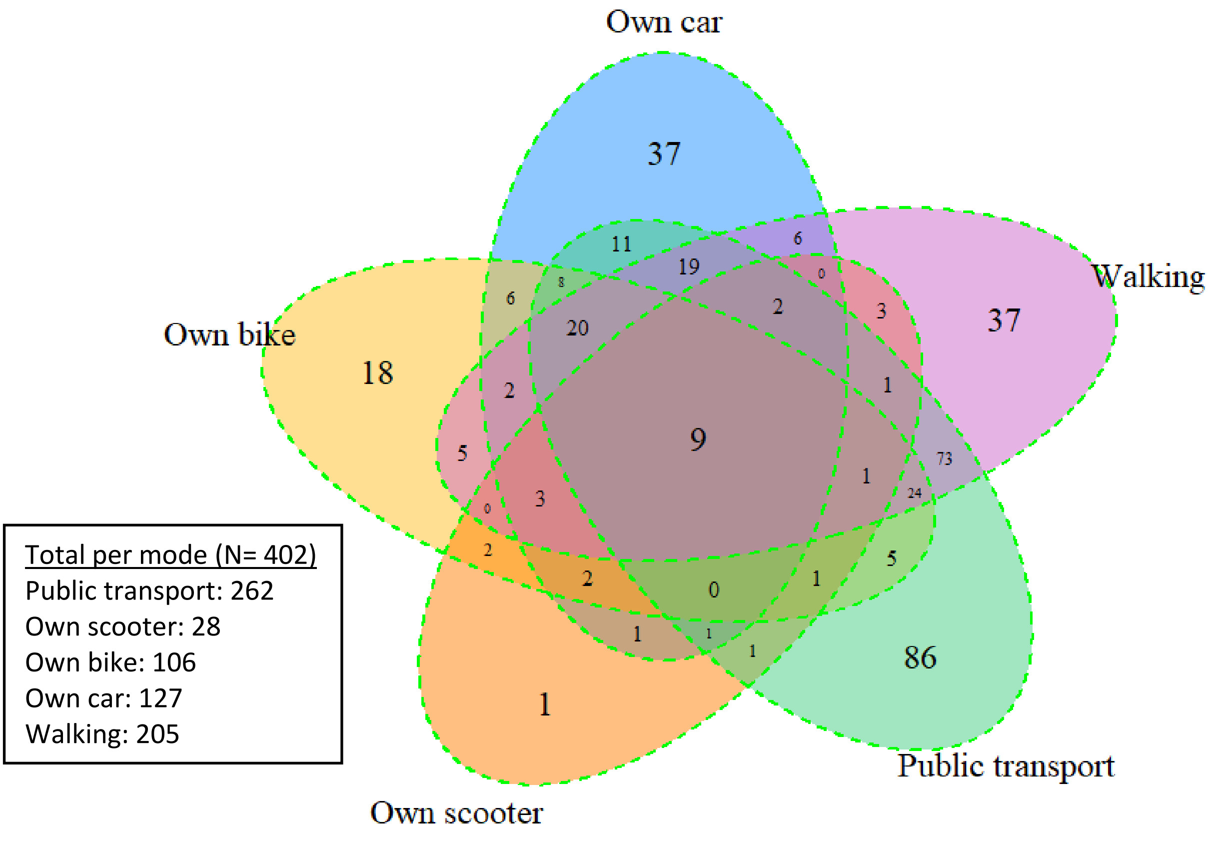


Figure 3-12. Alternative modes in case shared modes were unavailable

The above-mentioned findings could indicate that shared modes have a higher substitution rate for public transport than private car. However, the reader should consider that this section focuses only on current users of hubs and especially of shared mobility. As we revealed in the LCA analysis in 3.1.2, shared modes users are "mobility chameleons" who travel on average more often by public transport than their own car (see Figure 3-7 and Figure 3-8). Therefore, it is not surprising that they would choose public transport more than car for their trips. Similarly, the substitution rate of active modes is also in agreement with the profile revealed in the Latent Class Analysis.

Finally, the result that public transport and shared modes are interchangeable modes that could serve the same trip suggests that Smart mobility hubs where both systems are offered in the same locations could decrease the impact of disruptions such as temporary closure of a bike sharing system to travellers. More in-depth information on the contribution of hubs to the resilience of the mobility network are available in the Smarthubs Deliverable (D5.4 Resilience and vulnerability assessment).

The substitution patterns discussed here provide insight into which modes shared mobility and hub users have replaced after the introduction of hubs. The findings are valuable in recognising existing impact of hubs in mode share and mode choice. Shared modes have been revealed to be able to fill-in different trip stages and being able to support both unimodal and multimodal trips. Finally, these outputs could be considered by mobility planners and policy makers in the design of the network under disruptions in the shared mobility operation.

4 THE POTENTIAL OF MOBILITY HUBS

In this chapter we move further from analysing current behaviour and usage of hubs. We focus on the potential future impacts of hubs by analysing mode choice behaviour under stronger presence of shared mobility offers. We analyse both the unrestricted (Section 4.1) and restricted (section 4.2) willingness of people to travel by shared modes offered in hubs and identify potential modal shifts patterns. Section 4.3 provides insight into the barriers that have to be tackled to make hubs accessible and attractive to a broader population segment than the current users.

4.1 Shared mobility potential

This section addresses the modelling of the individual's likelihood to use shared mobility services offered at future mobility hubs. The respondents answered by selecting a level of a five-Likert item ("Very unlikely", Unlikely", "Neutral", "Likely", "Very likely"). The analysis illustrates respondents' likelihood of using bike and car sharing after the availability of these services in their neighbourhood.

The interest of the respondents for future use of bike and car sharing do not vary significantly. However, more participants showed higher confidence for travelling by shared bikes than cars. People who travel be their private car multiple days per week, are more reluctant in travelling by car sharing than by shared bikes. Non-users of public transport are overall not interested in shared mobility (Figure 4-1). On the contrary, around 30% of frequent public transport travellers stated that it is probable that they travel by both car and bike sharing (Figure 4-2).

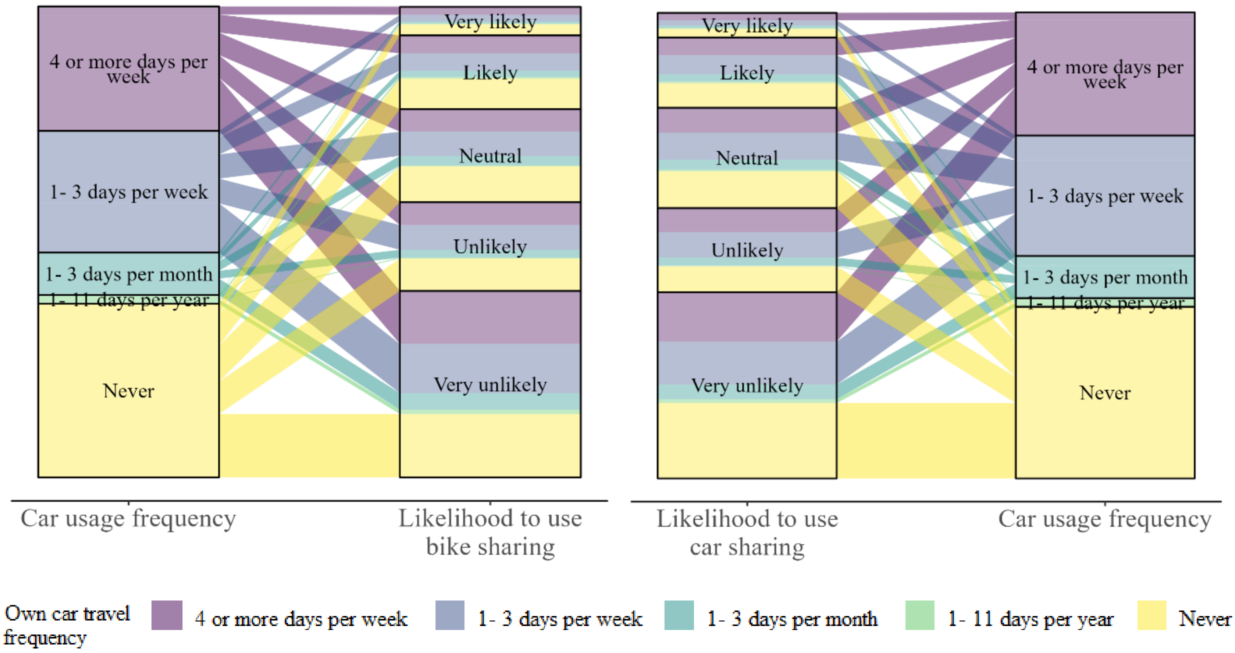


Figure 4-1. Likelihood of travelling by bike and car sharing in relationship to current travel frequency by own car

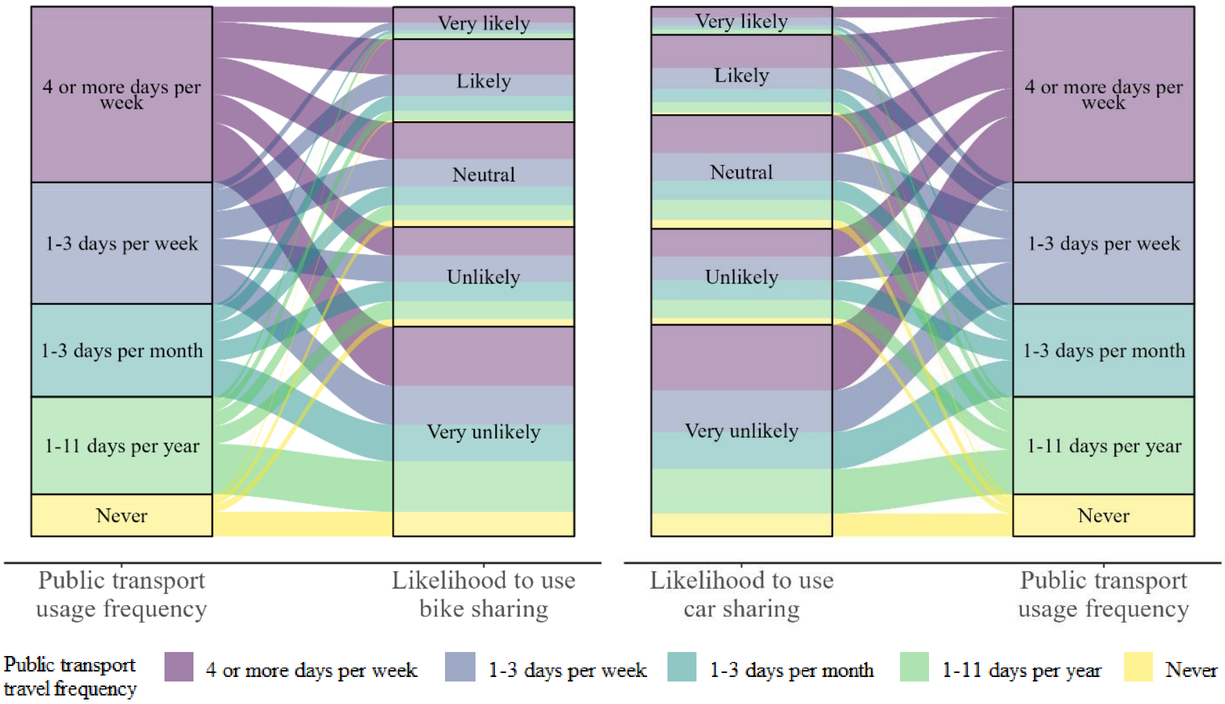


Figure 4-2. Likelihood of travelling by bike and car sharing in relationship to current travel frequency by public transport

To obtain insight into how different sociodemographic groups are likely to use mobility hubs, we perform group comparison statistical tests for gender and age group. The independent samples Wilcoxon test results are presented in Table 4-1. The table results show that people who do not depend on their private car have a higher interest in adopting bike and cargo bike sharing for their future trips than car-dependent individuals. Considering that car dependent people mostly belong in the “Own mobility dependent” group, we could claim that their reduced willingness to use these modes related to their preference for travelling by their own modes.

Gender appears to be an important determinant of likelihood to use shared mobility in the future. Except for car sharing, females seem more interested in travelling by shared modes to satisfy their future travel needs. In our analysis on current mobility behaviour we revealed that proportionally, fewer females are current users of mobility hubs and are less likely to be part of “mobility chameleons” group. The combination of these findings could lead us to assume although females are not current users, there is high potential in attracting female travellers in case the conditions are attractive to them. In chapter 4.3, we present the barriers that females face towards increasing their shared mobility use. A detailed analysis on barriers of various sociodemographic group is also available in D5.3, SmartHubs Equity Assessment (Garritsen, et al., 2023).

Table 4-1. Group comparison regarding interest to travel by hub-based modes in the future

Mode	Characteristic	Effect level	Test result
E-scooter sharing	Car usage	Non-users and infrequent car users	No difference
Bike sharing			Significant positive difference
Car sharing			No difference
Moped sharing			No difference
Cargo bike sharing			Significant positive difference
E-scooter sharing	Gender	Female	Significant positive difference
Bike sharing			Significant positive difference
Car sharing			No difference
Moped sharing			Significant positive difference
Public transport			Significant positive difference

4.2 Mode shift analysis – stated preference analysis

The stated preference mode experiment aimed at understanding people's willingness to shift to a mobility hub-based mode in case public transport and three different sharing services were available (bikes, e-scooter, cars) at the hub. The experiment data analysis in this chapter quantifies the potential changes in mode choice behavior due to the presence of hubs. The findings of the experiment data analysis add to the results of the reported likelihood that we examined in the previous section. The most significant contribution of the experiment analysis to the knowledge already gained via the likelihood analysis is the specification of the trip characteristics and circumstances that could affect people's willingness to modify their established mode preferences for mobility hubs modes.

4.2.1 Reference trips characteristics

The analysis focuses on how implementing more mobility hubs could influence mode choice for the most common trip purposes. As mentioned in the stated preference experiment description (see section 2.1.2.), people reported their most recent trip by a transport mode that does not belong to a hub. Considering all study areas, most respondents reported trips either by their own car or by public transport. Nevertheless, differences are noticeable in the four samples. Despite the distribution being similar between the Austrian and Belgian data, they differ from the Dutch sample in which trips by private bike are the second most common reference mode. Considering the higher share of cycling in the Rotterdam/The Hague region, this variance is not surprising. Unexpectedly, although cars are the most dominant mode in Munich city, the survey participants reported more trips by public transport than by private car. Own bikes also have a more increased presence in the dataset than in the current Munich modal split. These characteristics of the reported trips could have occurred due to the overrepresentation of younger people in the Munich dataset. Overall, despite the variance among the living labs and the disparities from the current modal split, the obtained dataset entails enough variance to investigate potential mode shift from the four "conventional" travel modes (Figure 4-3).

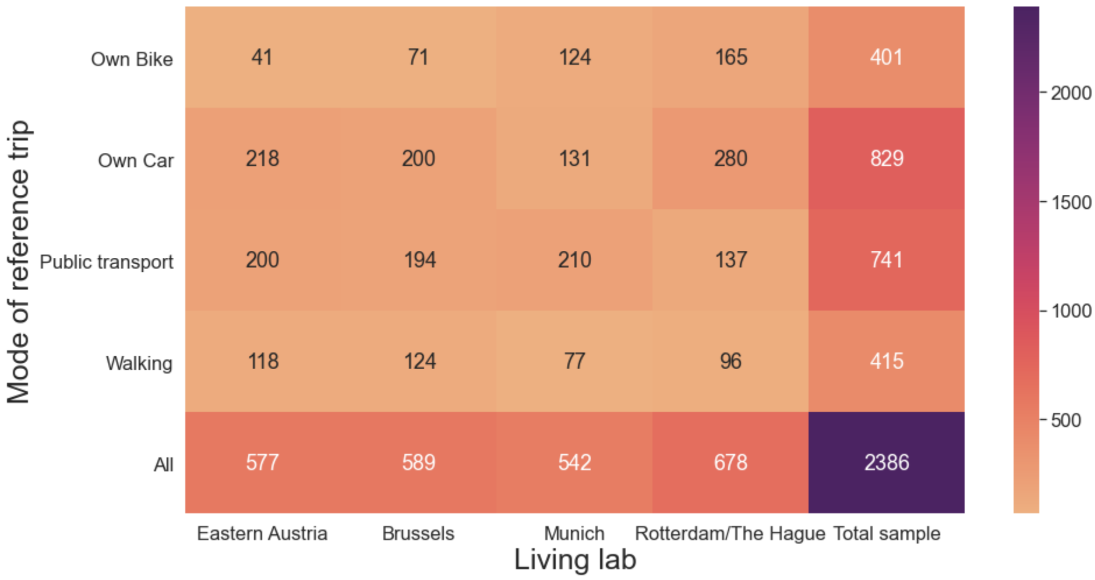


Figure 4-3. Reference modes distribution in the SP mode choice experiment

The trip distance is similarly distributed across the different modes in all areas. Nevertheless, we notice that for all modes, trips are consistently shorter in the Brussels Capital Region dataset. Respondents reported on-average shorter trips by active modes, with walking trips being even shorter than those by bike (Figure 4-4).

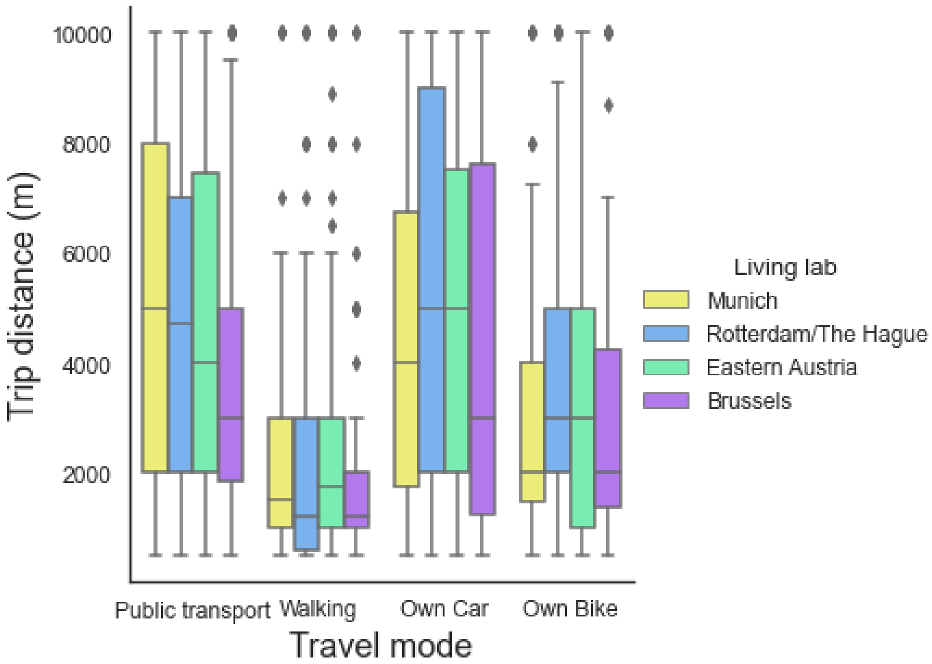


Figure 4-4. Trip distance distribution per reference mode in the stated preference experiment

The respondents' trips by car were mostly for work commuting or shopping purposes. Despite their shorter distances, most walking trips also satisfied shopping needs. The vast majority of the public transport trips are associated with commuting trips to/from work or education. However, the rest of the public transport related trips are almost equally distributed between leisure and shopping trips. Overall, regardless of the mode, shopping trips are shorter than for any other trip purpose. The latter is not surprising considering that the majority of the responses were gathered in urban areas in which shopping points of interest such super markets are available in short distance and high density (Figure 4-5 and Figure 4-6).

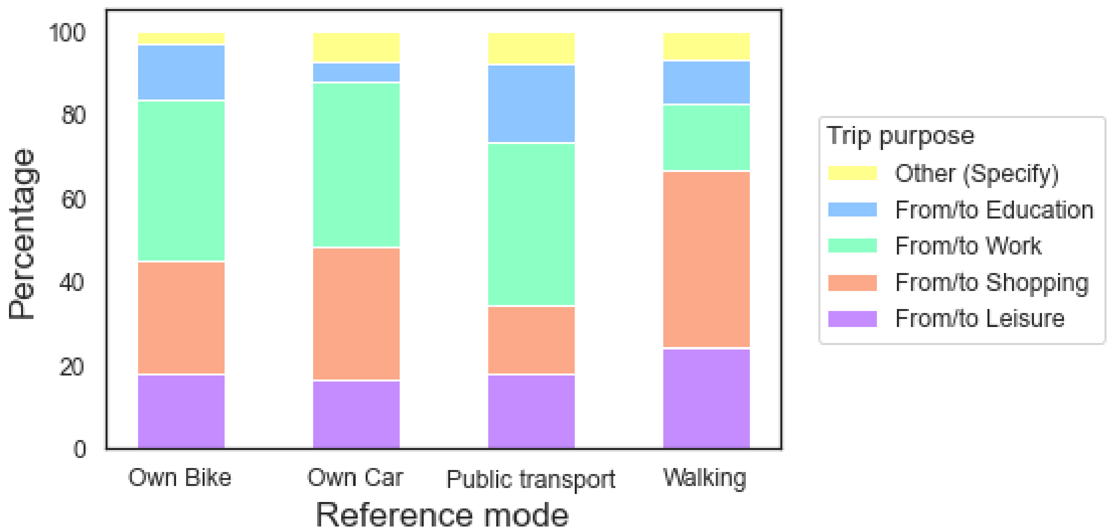


Figure 4-5. Trip purpose distribution per reference mode in the stated preference experiment

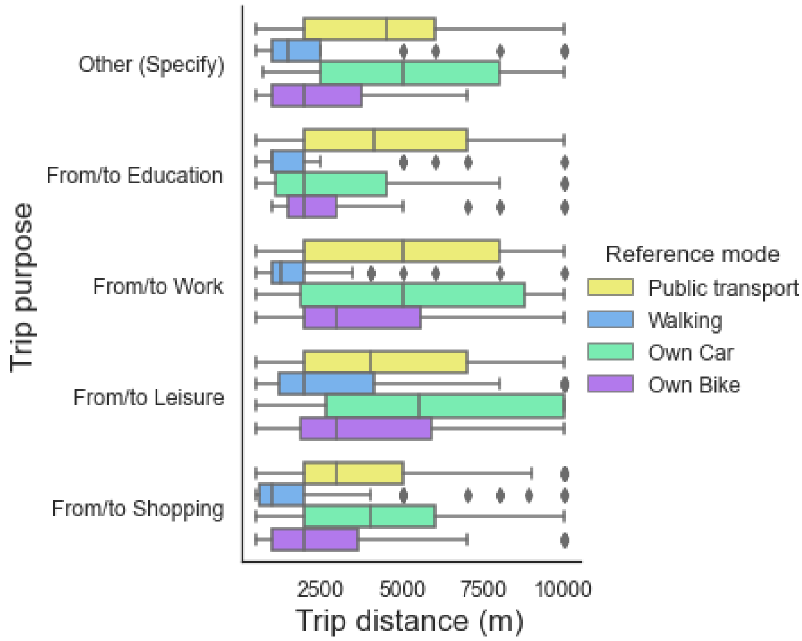


Figure 4-6. Distribution of trip distance per trip purpose and mode for the experiment reference trips

4.2.2 Stated Mode choice behaviour

The analysis of the initial (reference) modes and those selected in the scenarios can provide insight into the changes that mobility hubs could bring to mode choice behaviour. In this section, mode choice behaviour is analysed per living lab location.

Unlike the reference mode distribution which varies significantly between the City of Vienna and the rural areas of Lower Austria, the mode shift patterns are overall similar between the two regions (Figure 4-7). This finding indicates that despite the current differences in the modal split in urban and rural areas, mobility hubs could have similar impacts on them in terms of mode change, in case shared mobility and public transport services were available with the same characteristic such as access time and waiting time. In the City of Vienna, active mode trips by cycling and walking are those which suffer the most intense change in their modal split. In the scenarios, 50% of the people who reported a trip on foot changed to a hub mode in their stated choice. Public transport absorbed the majority (65%) of these changes, whereas e-scooter sharing was the least popular choice. The shift from trips by own bike was also mainly to public transport. Around one third (32%) of car travellers altered their private car for a different mode in the experiment scenarios. Although for them public transport was also the most preferred mode, these travellers were more willing to shift to car sharing than to shared micromobility. Unlike Vienna, in the rural Austria data, although public transport doubles its modal split in the scenarios, around 40% of individuals who reported a public transport trip, shifted to shared mobility and in particular to bike sharing (Figure 4-7).

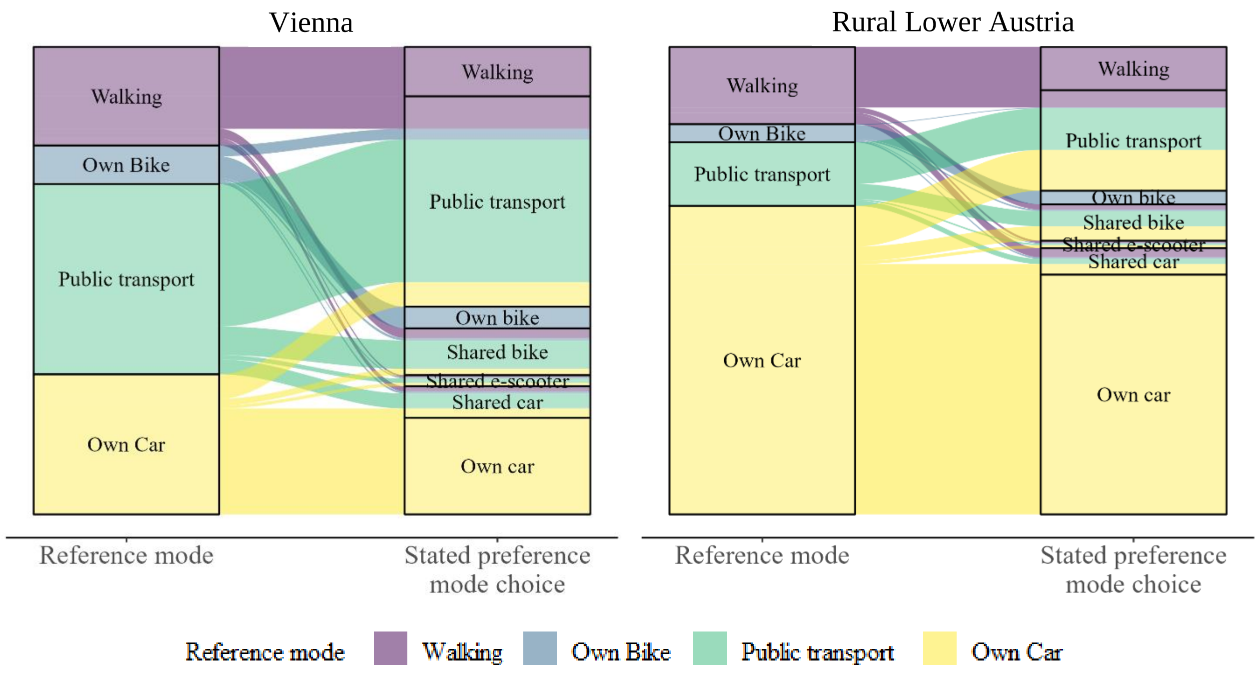


Figure 4-7. Stated mode choice per reference mode in Vienna city (left) and rural Lower Austria (right)

In Figure 4-8, the experiment results are visualised for the Brussels Capital Region and Munich. A distinct difference between the two areas is the more significant gain of shared bikes in Munich than in Brussels. Similarly, shared e-scooter has a higher modal split in Munich. Considering the younger sample in Munich, a great potential for increasing micromobility modal split appears for young people in Munich. Finally, in the Brussels sample people appeared stronger resistance in replacing walking and public transport with shared mobility.

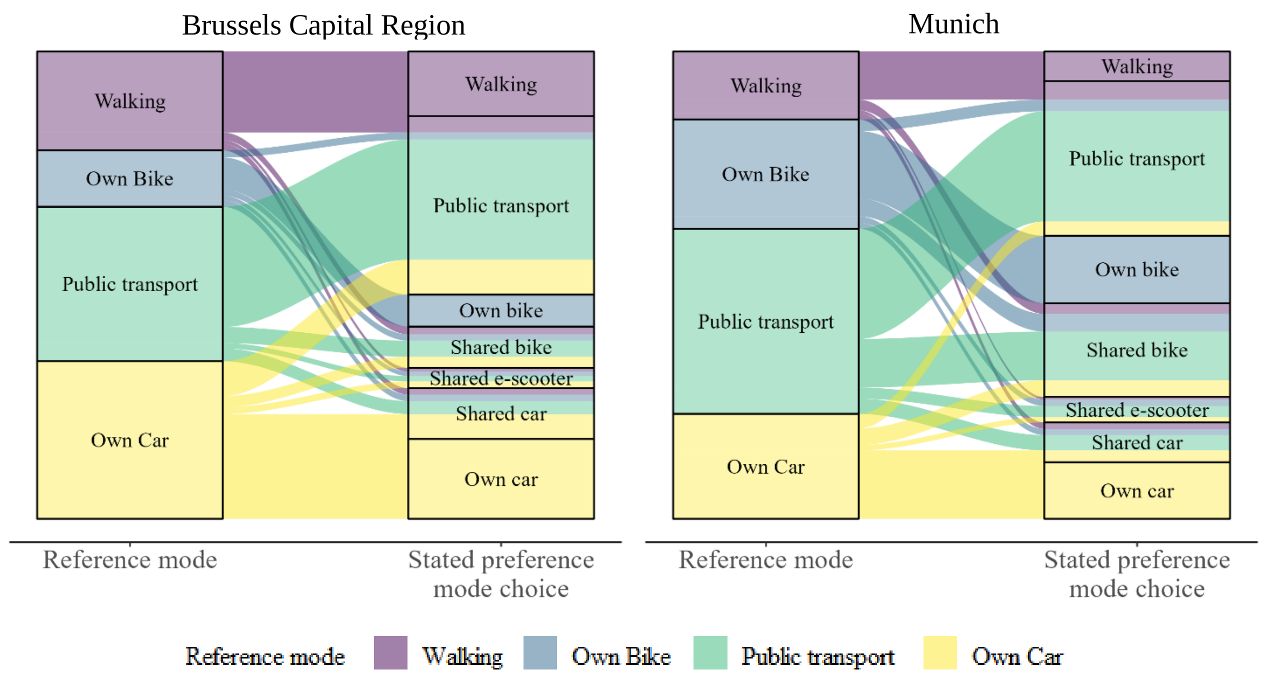


Figure 4-8. Stated preference mode choice per reference mode in Brussels Capital Region (left) and Munich (right)

In the Dutch study area, people seem more reluctant in changing their mode, in comparison for example to residents of Vienna. The stronger resistance is noticed among cyclist, the vast majority of whom (77%)

showed no interest in abandoning their own bike for a different mode. Although less intense than in the other living labs, walking is losing again the highest modal share in the experiment scenarios, with 35% of pedestrians deciding to travel by one of the hub-based vehicles. Out of all hub-modes, shared e-mopeds, similar with e-scooter sharing in the other study areas, they are the least popular choice in the Rotterdam/The Hague experiment scenarios (Figure 4-9).

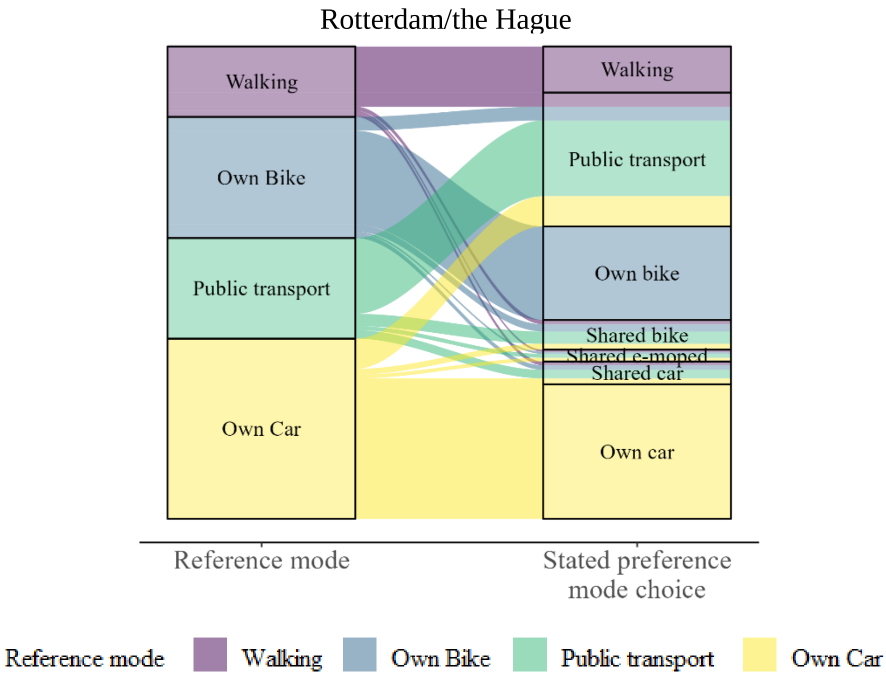


Figure 4-9. Stated preference mode choice per reference mode in Rotterdam/The Hague

The descriptive analysis on the mode substitution provides insight into potential changes in mode choice. Nevertheless, to understand more in depth under which circumstance people would be willing to travel by hub-based modes, we analysed the data further by modelling mode choice behaviour. In particular, we modelled behaviour based on the theories of Discrete Choice modelling and Utility maximisation. Utility maximisation theory on transport mode selection specifies that individuals choose their travel mode by comparing the utility level of the available alternatives and selecting to travel be the one with the highest utility (Ben-Akiva & Bierlaire , 1999). The models were estimated using the Biogeme (Bierlaire, 2023) package in python environment.

Considering that e-scooter and moped sharing are the latest additions to the shared micromobility offers, we examine how these two modes complement or compete with the more well-established bike sharing schemes by testing the existence of a nest in the choices of people. Our hypothesis is that people do not perceive the various micromobility modes as significantly different but they first decide whether they travel overall by shared micromobility or by any other mode. At a second stage, they choose the exact shared micromobility mode based on their preferences and the specific mode characteristics. To test this hypothesis a Nested Logit Model (Hensher & Greene, 2002) is suitable. As mentioned in the experiment design (see Section 2.1.1), In specific, we introduce the shared micromobility nest for shared bikes and e-scooters in the three datasets (Munich, Vienna, and Brussels Capital region) and the combination of shared bikes and e-mopeds for the Dutch dataset, (Figure 4-10 and Figure 4-11). It should mentioned that similar to the LCA analysis, for the Austrian living lab, the analysis here considers only data from the city of Vienna, to allow for a better comparison between the different urban areas of the Smarthubs sample.

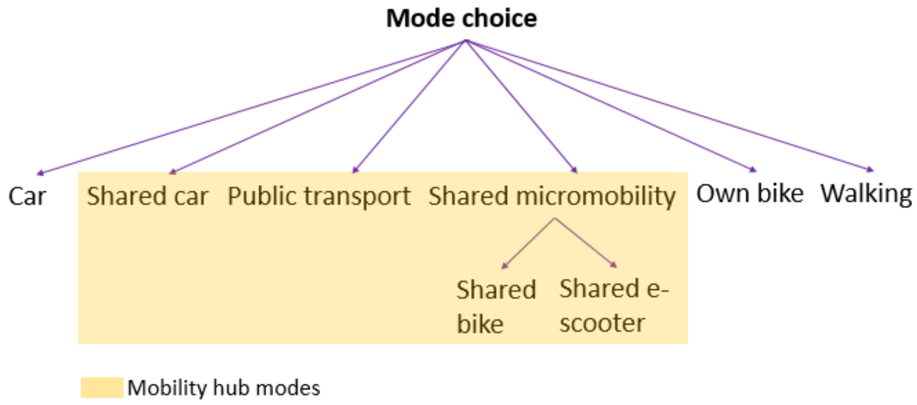


Figure 4-10. Mode choice behaviour conceptual diagram for three living labs: Munich, Brussels Capital, Eastern Austria

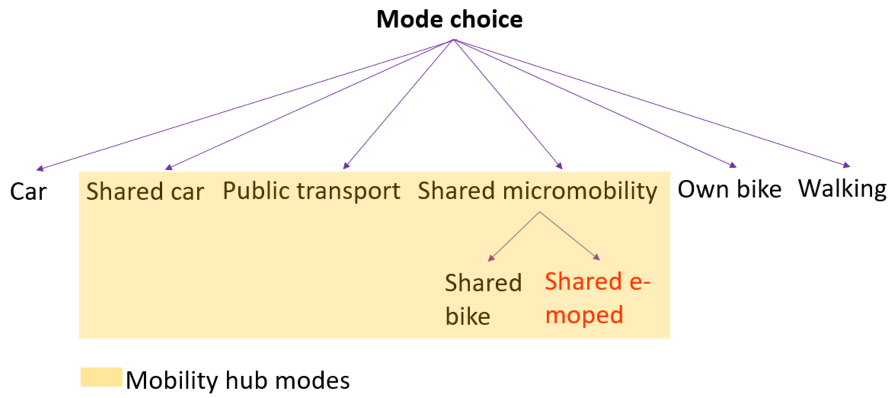


Figure 4-11. Mode choice behaviour conceptual diagram for the Rotterdam/The Hague living lab

Table 4-2 presents the results of the model estimation for the first Nested Logit Model. The values of only the significant variables are listed and empty cells represent insignificant parameters. The Viennese and Munich models reveal a significant shared micromobility nest (>1) between bike and e-scooter sharing, indicating that these two modes are perceived as similar, when comparing them to all other modes. In the Brussels data set, the nest effect is lower than 1 and as such the nest is insignificant, revealing that individuals perceived bikes and e-scooters as different one to each other, as much to any other mode included in the mode choice set. Regardless of the nest, the models show that various parameters influence the attractiveness of each mode. The model summary, shows that the models have good fit with adjusted rho-square value between 0.24 and 0.42, with the best for the analysis of the Vienna sample.

The estimation of the alternative specific constant (ASC) values was conducted in comparison to public transport as the base mode. The ASCs suggest that all shared modes are less preferred (negative values) than public transport. In Munich, people consider active modes as more attractive than public transport and bike is also more attractive in Vienna. However, in both these data sets, private car has also a positive ASC in comparison to public transport. In all models, the generic parameter of the costs is negative, supporting the negative utility of paying for transport by both own and shared mobility and an increasing attractiveness of the mode as the associated declines.

Unexpectedly, the models in Brussels and Munich reveal that access time is not affecting the probability of selecting a shared mode or public transport. Considering that the analysis was performed on stated preference data, it is possible this is a result of the range of access time values in the scenarios. In the experiment the access time was the same for all mobility hubs modes and varied between 1 and 6 minutes. The absence of sensitivity to these values indicates that people considered all these three walking times to reach shared mobility as equally acceptable. Although in the Viennese sample these finding hold for shared modes, people are sensitive to walking time to public transport stops and longer access time is associated with reduced selection of public transport.

Unlike Access time, vehicle travel time is associated with reduced likelihood of travelling by all shared modes, in all three cities. In Brussels, the shared e-scooter travel time has the strongest negative coefficient than the other three hub modes, revealing stronger sensitivity to travel time. Considering that costs for e-scooter trips is also per minute, the strong sensitivity to travel time could also be influenced by the correlation between time and costs for this mode.

Payment method is an important determinant of mode choice in all study areas. Via their mode choices the survey participants suggest that they consider the transition to exclusive app-based payment as a positive aspect of shared modes, especially significant for e-scooter and car sharing. On the contrary, such a change is not perceived as positive for public transport users. This finding could be explained via the effect of age in mode choice. The models suggest that being young is more positively correlated with travelling by shared micromobility and reduces the chances of using private car in comparison to travelling by public transport. Considering that younger people have overall higher digital skills and affinity with smartphone apps, it is not unexpected that they, as the main shared mobility users, perceive app-based mobility as a positive characteristic.

A gender effect is revealed by the estimated models. This gender effect is reverse than the one found for the females interest for future hub-based trips (see Table 4-1). Two conclusions can be drawn. The output of the models (Table 4-2) highlight disparities between the different areas, revealing a local context effect. In addition, while females shows a significantly higher interest to embrace shared mobility for future trips, they still appear more reluctant when asked to shift to shared mobility for their present trips. In specific, the models estimation shows that females are more likely to travel by private car than shared mobility. The Brussels dataset uncovers a statistically significant stronger preference of females for walking and travelling by public transport than by private car whereas in Vienna, females are more positively related to travelling by own car than shared or public modes. In Munich females have a reduced likelihood of choosing shared modes.

Trip characteristics are significant factors of mode choice behaviour, in particular in regards the decision to travel by own car (Table 4-2). The results vary among the three European areas. While in Munich private car is less attractive than walking to travel for leisure, in Brussels Capital Region car is the most preferred mode. In the Viennese sample, an increased will to travel by public transport over private car was found for leisure trips in comparison to other trip purposes.

Pleasant weather has opposite effect in the Munich and Vienna experiments. On the one hand, good weather is associated with travelling by higher likelihood of travelling by any other mode instead of walking in Munich. Shared mobility and active modes are more attractive than walking under pleasant circumstances. On the contrary, the Viennese respondents declared that in case of pleasant weather, walking is their default choice and shared micromobility becomes less attractive. Further interpretation and generalisation of the weather effect is not straightforward as in the present experiment weather was reported by each individual and there was no control over how each individual distinguishes between pleasant and unpleasant circumstances. Furthermore, cultural differences could also have influenced the definition of pleasant and unpleasant weather. Finally, since the data collection took place in the middle of winter, the two levels of the weather could have been perceived as more or less pleasant winter weather rather than overall pleasant or unpleasant circumstances.

Table 4-2. Mode choice model results (Brussels Capital Region, Munich, Vienna)

Attribute	Munich	Brussels	Vienna
Nested shared micromobility	1.08	0.59	1.85
Mode characteristics			
Alternative specific constants			
Public transport	(reference)	(reference)	(reference)
Walking	1.03*	1.57*	-
Shared bike	-0.56*	-2.33*	-1.62*
Shared e-scooter	-0.92*	-2.08*	-1.91*
Shared car	-0.94*	-1.37*	-1.92*
Own car	0.78*		0.46*
Own bike	1.25*		0.58**
Access time			
Shared modes			
Public transport			-0.05*
Travel time			
Public transport	-0.05*	-0.03*	-0.04*
Walking	-0.02*	-0.02*	-0.03*
Shared bike	-0.05*	-0.04*	-0.06*
Shared e-scooter	-0.1*	-0.1*	-0.06*
Shared car	-0.1*	-0.06*	-0.06
Own car			
Own bike	-0.02*		-0.01*
Travel costs	-0.08*	-0.13*	-0.17*
Payment only via mobile app			
Public transport	-0.5*	-0.65*	-0.35*
Shared bike			
Shared e-scooter	0.3*		
Shared car	0.31*	0.22**	
Trip characteristics			
Trip purpose: leisure			
Public transport		0.75*	(reference)
Walking	(reference)	(reference)	
Shared bike			
Shared e-scooter			
Shared car	0.51***		
Own car	-0.41	0.79*	-0.77*
Own bike	0.96*	0.78*	
Weather circumstances: pleasant weather			
Public transport	0.97*	0.8*	-0.59*
Walking	(reference)	(reference)	(reference)
Shared bike	0.87*		-0.61*
Shared e-scooter	0.61*	0.81*	-0.67*
Shared car	0.87*		
Own car	0.71*		
Own bike	1.53*		-1.52*
Individual characteristics			
Female			
Public transport		0.4*	-0.38*
Walking		0.45*	
Shared bike	-1.74**		-0.91*
Shared e-scooter	-0.44**		-1.15*
Shared car	-0.38*		-0.78*
Own car	(reference)	(reference)	(reference)
Own bike		-0.91*	-0.83*

Young adults	Munich	Brussels	Vienna
Public transport	(reference)	(reference)	(reference)
Walking			
Shared bike	0.19**	1.11*	0.71*
Shared e-scooter	0.43*	0.69*	1.04*
Shared car		0.82*	0.67*
Own car	-1.28*	-0.6*	
Own bike	-0.42*	1.1*	-0.85*
Model summary			
Sample size	3174	3522	3444
Initial-log likelihood	-4828.534	-5408.701	-5275.1332
Final log-likelihood	-3563.464	-3624.226	-3020.877
Likelihood ratio test	2530.139	3568.951	4508.509
Adjusted Rho-square	0.253	0.322	0.417
BIC	7474.627	7607.79	6465.263
AIC	7212.929	7336.451	6145.755

*Significant at 95% confidence level, ** Significant at 90% confidence level

Table 4-3 summarises the Nested Logit Model results for Rotterdam/The Hague. The model has a very good fit with an adjusted Rho square equal to 0.49. A nested choice of shared bikes and mopeds is found in this model indicating that individuals perceive the two modes as more similar to each other than to the rest of the modes in their mode choice set. The alternative specific constants (ASCs) values show that everything else being equal, people living in Rotterdam/the Hague prefer travelling by their own bike and own car over public transport. Similar to the ASCs in the previous model (Table 4-2), all shared modes are less attractive then public transport.

People were not sensitive to the access time range they faced but vehicle travel time is a significant variable. Unlike the previous model, the strongest sensitivity to travel time is found for travelling by own car. For trips by own bike, travel time is significant but has a weaker influence to the probability of choosing the mode. The model estimation reveals that payment via an app is again negatively related to travelling by public transport, although no influence for shared mobility was found. Although, trip purpose is also not related to the likelihood of travelling by shared micromobility, it is a significant factor regards choice of car sharing. In specific, car sharing is more attractive for leisure trips in comparison to walking.

As seen in Table 4-3, age and gender are suitable for explaining mode choice behaviour in the area of Rotterdam/The Hague. Females are more inclined to choose shared car and their own bike than their private car in comparison to males. The two considered genders do not perceive public transport differently in the context of the trips presented in the experiment. Younger people are, similarly to the other three study areas, more positively related to travelling by shared mobility than public transport for the trips reported in the experiment. Younger age is negatively associated to travelling by private modes.

Table 4-3 Mode choice model results (Rotterdam/The Hague)

Attribute	Coefficient
Nested shared micromobility	1.55*
Mode characteristics	
Alternative specific constants	
Public transport	(reference)
Walking	1.72*
Shared bike	-1.18*
Shared moped	-1.21*
Shared car	-1.90*
Own car	2.57*
Own bike	2.05*
Access time	
Shared modes	

Public transport	
Travel time	
Public transport	-0.07*
Walking	(reference)
Shared bike	-0.09*
Shared moped	-0.08*
Shared car	-0.09*
Own car	-0.13
Own bike	-0.03*
Travel costs	-0.13*
Payment only via mobile app	
Public transport	-0.22*
Shared bike	
Shared e-scooter	
Shared car	
Trip circumstances	
Leisure trip purpose	
Public transport	-1-73**
Walking	(reference)
Shared bike	
Shared moped	
Shared car	0.64*
Own car	-0.59*
Own bike	-0.91*
Weather circumstances: pleasant weather	
Public transport	-0.68**
Walking	(reference)
Shared bike	-1.81**
Shared moped	-1.46*
Shared car	
Own car	-1.23*
Own bike	-1.07*
Individual characteristics	
Young adults	
Public transport	(reference)
Walking	
Shared bike	0.93*
Shared moped	1.21*
Shared car	0.56*
Own car	-0.62*
Own bike	-0.36*
Females	
Public transport	
Walking	-0.49*
Shared bike	
Shared moped	-0.42**
Shared car	0.56*
Own car	(reference)
Own bike	0.39**
Model summary	
Sample size	3880
Initial-log likelihood	-6061.195
Final log-likelihood	-3045.373
Likelihood ratio test	6031.64
Adjusted Rho-square	0.489
BIC	6520.453
AIC	6194.746

4.3 Barriers to shared mobility usage

The present section provides insight into the barriers that currently discourage shared mobility usage. Table 4-4 displays the results from the survey respondents' answers to the various barriers statements. The statements were only presented to non-users of each shared service and are not restricted by any personal characteristic to use each mode. For instance, only non-users of bike sharing who reported ability to ride a bike faced the bike sharing-related statements. Each respondent could select one or more barriers that match their circumstances.

As seen in Table 4-4, the preference to private modes is the most common reason for not travelling by bike, car, and moped sharing. For shared e-scooters the feeling that they do now fulfil any travel need is the most frequently chosen statement. A noticeable different between e-scooters and the rest of the modes, is that a much higher percentage of people reported that safety concerns have prevented them from travelling by these modes. Similarly, although at least 15% of the respondents stated that the high usage cost is the reason that they do not travel by any shared scheme, the proportion is the highest for e-scooter sharing.

Considering that moped and e-scooter sharing are the most recent additions to the shared mobility spectrum, it is not surprising, that many people, 17% and 16%, respectively, mentioned that they lack knowledge of how to use these vehicles.

Table 4-4 Overview of barriers to shared mobility usage

	Shared mobility			
Barrier statements	Bike N= 1672	E-scooter N=895	Car N=1473	Moped N=460
"Have never heard of it"	7%	6%	5%	3%
"It is to expensive"	15%	21%	18%	16%
"I have to walk too far to reach a vehicle"	13%	15%	12%	7%
"I think it is too dangerous"	7%	29%	2%	12%
"I do not trust shared vehicles"	7%	11%	8%	8%
"I do not know how to use it"	5%	16%	4%	17%
"I do not feel that it can fulfil any of my travel needs"	15%	31%	12%	14%
"I tried in the past and was disappointed with the experience"	2%	3%	1%	1%
"I prefer using my own vehicles"	55%	29%	46%	63%

Most frequent barrier Least frequent barrier

Deliverable 5.3 provides an in-depth discussion on the barriers faced by the various vulnerable-to-exclusion population groups (Garritsen, et al., 2023).

5 CONCLUSIONS

This chapter summarises the findings obtained via the plethora of analysis conducted on the mobility hubs present and future impacts. The present findings are also discussed in regards to their relevance to policy making. Finally, after reflecting on the limitations of our approach we draw recommendations for future studies.

5.1 Main Findings

The analysis uncovered that there is a population group, the so-called "Mobility chameleons", accounting for around 30% of the population, that has embraced shared mobility and benefits from the introduction of shared mobility schemes. People with this mobility profile are frequent shared mobility users but satisfy their travel needs by being flexible in regards to their travel mode selection. They seem to alternate and combine various shared, private and public transport modes to conduct their trips. Higher digital skills and income are consistently positively correlated to the probability of belonging to the "mobility chameleons" cluster. However, most people have not yet transformed to "mobility chameleons" and are still reluctant and see no added value in using shared instead of private modes. Nevertheless, both the unrestricted and restricted mode shift analysis indicated that there is more potential for shared mobility once it increases its presence and accessibility.

The study also revealed that the latest additions to the shared mobility system, e-scooter and moped sharing, influence mode choice behaviour. People seem to perceive these modes as similar to shared bikes. As such, on the one hand, these micromobility modes seem to compete with bike sharing in terms of modal split. On the other hand, these services could complement bike sharing when the latter is unavailable due to either vehicle unavailability in stations or system disruption. Despite this nest in the mode choice behaviour of the stated preference experiment, the analysis on the trips that people currently conduct by shared mobility suggests significant differences. For instance, while both bike and e-scooter sharing are used for unimodal trips, people select the latter most commonly as access mode to public transport.

The present research suggests that a new mobility gap is emerging: the digital mobility gap. All different analysis confirm that people with low digital mobility skills are less attracted to, mostly due to due their reduced possession of smartphone. The finding strengthens the definition of the Smarthubs integration ladder which suggests that smart mobility hubs, are only achievable via the provision of integrated digital access to mobility service that respect the universal design principles. Indeed, in case the latter are not considered, mobility hubs, but also individual shared mobility systems, would fail their mission to enhanced mobility accessibility.

Finally, the present work highlights the effect of local context in the mobility hubs impacts. While some findings are consistent among the different European regions, there is significant variation in the determinants of travel behaviour and in the populations' needs and preferences from mobility hubs.

5.2 Policy implications

Policy makers should consider the results of this deliverable to design and prepare future mobility policies. The higher interest of young people on shared mobility and their increased presence in the "mobility chameleon" class indicate that the future mobility demand can differ from the patterns established by older generations. Taking measures that ensure the possibility of mobility hubs to accommodate the various present and evolving needs of this generation, for example due to life changing events such as having kids or home location change, could increase the probability that this generation maintains the usage of shared and, consequently, sustainable mobility in the future.

The digital mobility gap, highlighted by our findings, could be avoided by decreasing or completely removing the barriers faced by people with reduced digital mobility skills. Hub operators could try to offer alternative, "conventional" access to their vehicles, e.g. via customer cards. Trainings and information distribution on the usage of mobility apps could also alleviate the gap. Considering the needs of people with low digital skills is also crucial for public transport services. Since the latter is, and should remain, the backbone mode for people with a wide range of sociodemographic background, the transition to digitalised public transport systems should follow a process than ensures the accessibility by all population groups.

5.3 Limitations and recommendations

The present study modelled mode choice behaviour based on multiple determinants but ignored the influence of the built environment on decision making. The consideration of the local context provided some relevant insight but did not quantify the contribution of specific environment factors, e.g. micromobility infrastructure coverage and availability of WiFi in the public space. Future analysis could focus on how such factors affect the attractiveness of shared mobility. Similarly, due to length limitations the Smarthubs standardised survey did not capture people's attitudes. Attitudes towards multiple aspects, such as shared economy, electrification of shared vehicles and the trust in publicly offered services, could be decisive in people's decision to use shared e-mobility. Future data collection efforts could include attitudinal questions and enable the analysis of their influence on mode choice behaviour in the context of mobility hubs.

To conclude, the impact analysis in the various living lab areas suggested that further international studies are needed to obtain deeper insight the impacts of mobility hubs under different socioeconomic and mobility circumstances.

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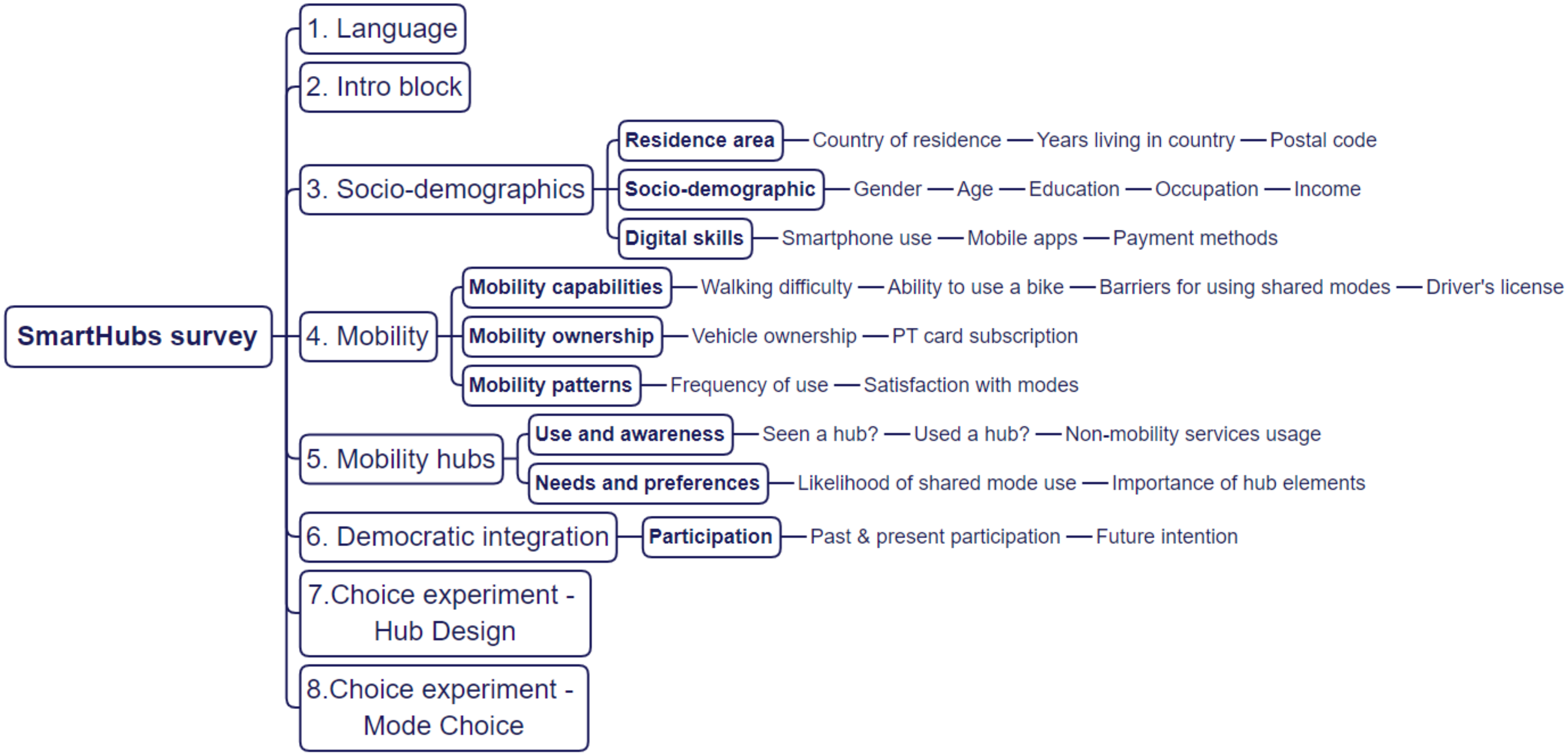
APPENDIX. SMARTHUBS STANDARDISED SURVEY

This survey was developed by the University of Twente (The Netherlands) and the University of Natural Resources and Life Sciences (BOKU) (Vienna, Austria) in December 2022, as part of the SmartHubs Project.

Implemented on Qualtrics by the researchers: Roxani Gkavra (roxani.gkavra@boku.ac.at) and Dr. Anna Grigolon (a.b.grigolon@utwente.nl)



1. Language				
ID	Question	Answer Type	Answer set	Routing
Q605	Language/Sprache/Taal/Langue	Drop-down list	Deutsch English Français Nederlands Nederlands-België	-

2. Intro Block				
ID	Question	Answer Type	Answer set	Routing
Q5	Country of residence	Select one	○ Austria ○ Belgium ○ Germany ○ The Netherlands	Q605
Introduction	**Thank you for your interest in our survey!** The SmartHubs project aims to examine how mobility hubs (dedicated on-street locations where travelers can choose from different shared mobility and public transport options) can be a game changer toward inclusive sustainable urban mobility and accessibility. For the design of an ideal mobility hub, citizens' desires and needs are heard. Public transport and shared modes (bikes, scooters or cars) are available for you. There are services available such as public toilets, information kiosks, waiting areas, and urban gardens. You can plan, book, and pay for a trip combining different modes of transport using one smartphone app.  In order to participate in the survey, you must be older than 16 years. The survey will take around 20 minutes. Further information on the Smarthubs project can be found online at the project website You can also contact us by email the responsible researchers Dr Anna Grigolon and Roxani Gkavra at smarthubs@boku.ac.at			
Q30	Consent: Your participation is voluntary: you are not obliged to take part and in case you refuse, this will have no consequences for you. After starting the survey, you can	Select one	I hereby confirm that my participation in this survey is voluntary, that I have been adequately informed about the purpose of the study, and that I can withdraw my	-

	quit at any time and you do not have to provide a reason for doing so. The collection and processing of data are in accordance with the legal principles imposed by the European General Data Protection Regulation (GDPR). In addition, any data collected from you will be anonymised and will be stored and used only for the purposes of the Smarthubs project.		participation from this survey at any time for any reason.	

3. Socio-Demographics

ID	Question	Answer Type	Answer set	Routing
Gender	Gender	Select one	○ Female ○ Male ○ Other ○ Prefer not to say	-
Age	Age (in years).	Text box	○	-
Years living	How many years have you lived in [Q5]?	Select one	○ I was born in [Q5] ○ More than 10 years but I was not born here ○ 6-10 years ○ 1-5 years ○ Less than 1 year ○ Prefer not to say	-
Zipcode home	What is the postcode of your home location in [Q5]?	Text box		-
Education	What is the highest level of education you have completed?	Select one	○ Compulsory education or less ○ High school graduate ○ Senior high school ○ University undergraduate degree ○ MSc/MA/PhD or other equal level ○ Other	-
Occupation	What is your main occupation status?	Select one	○ Employed (working full/part time) ○ Self-employed (working full/part time) ○ Working in household or other unpaid activity ○ Student ○ In retirement ○ Unemployed ○ Unable to work	
Income	What is your net household income per month?	Select one	○ Up to 1600 Euros ○ 1601-3200 Euros	

			○ 3201-4800 Euros ○ 4801-6400 Euros ○ >6401 Euros ○ Do not know	
Home office	How often do you work from home on average?	Select one	○ Never ○ Less than 1 day per month ○ 1 to 3 days per month ○ 1 to 3 days per week ○ 4 or more days per week	Occupation→Employed (working full/part time) OR →Self-employed (working full/part time)
adults	Number of adults (at least 18 years old) in your household?	Select one	○ 1 ○ 2 ○ More than 2	
kids	Number of non-adult members (children, teenagers) in your household?	Select one	○ None ○ 1 ○ 2 ○ More than 2	
Smartphone usage	Do you have a smartphone with internet connection?	Select one	○ Yes ○ Yes, but I use it only for calls/ messaging and other offline activities ○ No	-
nophone	Which of the following have you used in the last year? Select all that apply.	Multiple choice	☐ Credit card to purchase goods at a store/supermarket ☐ Credit card to shop online ☐ Credit card to purchase transportation tickets	Smartphone usage → No OR → Yes, but I use it only for calls/ messaging and other offline activities
withphone	For which of the following functions have you used your smartphone within the last year?	Multiple choice	☐ App to transfer money to someone ☐ App to plan a trip with your own vehicle (car, bicycle) or walking (for example, Google maps) ☐ App to plan a trip by public transport ☐ App to buy tickets or seat reservation for public transport ☐ App to reserve/book/pay for a shared vehicle (bike, car, scooter) ☐ None of the above	Smartphone usage → Yes

4. Mobility

<table>
<tr><th>ID</th><th>Question</th><th>Answer Type</th><th>Answer set</th><th>Routing</th></tr>
<tr><td>Q142</td><td>Which of the following vehicles are available for you to use in your household?</td><td>Multiple choice; text</td><td>☐ Bike
☐ E-bike
☐ Car
☐ Moped/Motorcycle
☐ *E-scooter (except NL)
☐ Other (please specify)
☐ None of the above</td><td>*Q5 → is not NL</td></tr>
<tr><td>Q82</td><td>How many cars do you own in your household?</td><td>Select one</td><td>○ 1
○ 2
○ More than 2</td><td>-</td></tr>
<tr><td>Q13</td><td>Do you have any physical difficulty when walking?</td><td>Select one</td><td>○ No
○ Yes</td><td>-</td></tr>
<tr><td>Q14</td><td>What kind of assistance do you use when walking?</td><td>Multiple choice; text</td><td>☐ I do not use any assistance
☐ Wheelchair
☐ Rollator
☐ Mobility scooter
☐ A service dog
☐ Caretaker
☐ Other, please specify</td><td>Q13→ Yes</td></tr>
<tr><td>Q8</td><td>Can you ride an e-scooter? </td><td>Select one</td><td>○ No
○ Yes
○ Do not know/have never tried</td><td>Q5 → is Austria OR Belgium OR Germany</td></tr>
<tr><td>Q32</td><td>How often do you use the vehicles you own in your household?</td><td>Matrix table</td><td><table>
<tr><th></th><th>4 or more days per week</th><th>1-3 days per week</th><th>1-3 days per month</th><th>1-11 days per year</th><th>Never</th></tr>
<tr><td>Car as a driver or passenger</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>E-scooter</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bike/e-bike</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Moped/motorcycle</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td><td>Q142→bike OR e-bike OR Car OR Moped/Motorcycle

Q142→ e-bike IF Q5→ not NL</td></tr>
</table>

Q153	How often do you walk to reach activities (excluding leisure walks)?	Select one	○ 4 or more days per week ○ 1-3 days per week ○ 1-3 days per month ○ 1-11 days per year ○ Never	-
shared_modes_intro	In the remaining of the survey many questions will refer to Shared transport modes:  Shared bike/e-bike: provides users with access to bicycles at a variety of pick-up and drop-off locations. Bikes are available via an application, a customer card, or a machine.  Shared e-scooter: allows access to e-scooters at various locations. E-scooters are available via an application, a customer card, or at a machine.  Shared car: usually offered at dedicated locations. Users need to have a driving license. Payment is common via an application, an online account on a website or at a machine.  Shared moped/scooter: allows access to mopeds/scooters at various locations. Most commonly, people can access a scooter via a mobile application.  Shared cargo bike/e-bike: provides users with access to cargo bicycles at a variety of pick-up and drop-off locations. Cargo bikes are available via an application, a customer card, or at a machine.			Q5→ Austria, Germany, Belgium
shared_modes_intro_NL	In the remaining of the survey many questions will refer to Shared transport modes: 			Q5→ is NL

<table>
<tr><td></td><td colspan="3">Shared bike/e-bike: provides users with access to bicycles at a variety of pick-up and drop-off locations. Bikes are available via an application, a customer card, or a machine.

Shared car: usually offered at dedicated locations. Users need to have a driving license. Payment is common via an application, an online account on a website or at a machine.

Shared moped/scooter: allows access to mopeds/scooters at various locations. Most commonly, people can access a scooter via a mobile application.

Shared cargo bike/e-bike: provides users with access to cargo bicycles at a variety of pick-up and drop-off locations. Cargo bikes are available via an application, a customer card, or at a machine</td><td></td></tr>
<tr><td>Q39</td><td>How often do you travel by the modes listed below?</td><td>Matrix table</td><td><table>
<tr><td></td><td>4 or more days per week</td><td>1-3 days per week</td><td>1-3 days per month</td><td>1-11 days per year</td><td>Never</td></tr>
<tr><td>Taxi/Uber</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bus, tram, metro</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Train</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>*Shared e-scooter</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared bike/e-bike</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared moped/motorcycle</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared car as driver or passenger</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td><td>* Q5→ is not NL</td></tr>
<tr><td>Q38</td><td>How satisfied are you overall with travelling by the following modes in your everyday life?</td><td>Matrix table</td><td><table>
<tr><td></td><td>Very dissatisfied</td><td>Dissatisfied</td><td>Neutral</td><td>Satisfied</td><td>Very satisfied</td></tr>
<tr><td>Bus, Tram, Metro</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td><td>Q142</td></tr>
</table>

			Own car | | | | | Own bike | | | | |	
Q59a	What are the main reasons why you never travelled by **shared e-scooter** in the last year? Check all that apply	Multiple choice; text	☐ Have never heard of it ☐ It is too expensive ☐ I have to walk to far to reach a vehicle ☐ I think it is too dangerous ☐ I do not trust using this vehicle ☐ I do not feel that this vehicle can fulfil any of my travel needs ☐ I tried in the past and was disappointed with the experience ☐ I prefer using my own vehicle ☐ Other (please specify)	Q5→ is not NL AND Q39 →e-scooter is NEVER
Q198	What are the main reasons why you never travelled by **shared scooter/moped** in the last year? Check all that apply	Multiple choice; text	☐ Have never heard of it ☐ It is too expensive ☐ I have to walk to far to reach a vehicle ☐ I think it is too dangerous ☐ I do not trust using this vehicle ☐ I do not feel that this vehicle can fulfil any of my travel needs ☐ I tried in the past and was disappointed with the experience ☐ I prefer using my own vehicle Other (please specify)	Q39 →shared moped/motorcycle is NEVER
Q42	What are the main reasons why you never travelled by shared car in the last year? Check all that apply	Multiple choice; text	☐ Have never heard of it ☐ It is too expensive ☐ I have to walk to far to reach a vehicle ☐ I think it is too dangerous ☐ I do not trust using this vehicle ☐ I do not feel that this vehicle can fulfil any of my travel needs ☐ I tried in the past and was disappointed with the experience ☐ I prefer using my own vehicle Other (please specify)	Q39 →shared car is NEVER
Q43	What are the main reasons why you never travelled by **shared bike/e-bike** in the last year? Check all that apply	Multiple choice; text	☐ Have never heard of it ☐ It is too expensive ☐ I have to walk to far to reach a vehicle ☐ I think it is too dangerous ☐ I do not trust using this vehicle ☐ I do not feel that this vehicle can fulfil any of my travel needs ☐ I tried in the past and was disappointed with the experience ☐ I prefer using my own vehicle	Q39 →shared bike/e-bike is NEVER

			Other (please specify)	

5. Mobility hubs: awareness and future use				
ID	Question	Answer Type	Answer set	Routing
Q143a	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighborhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance 2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker) 4. An integrated mobile application for planning, booking and paying different transport modes  Examples from Austria:  			Q5→ Austria

Q143b	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighbourhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance 2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker) 4. An integrated mobile application for planning, booking and paying different transport modes  Example from the Netherlands: 	Q5→ Netherlands
Q143c	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighbourhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance 2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker)	Q5→ Germany

	4. An integrated mobile application for planning, booking and paying different transport modes  Examples from Germany:  	
Q143**a** (should have been d)	This part of the survey is focused on mobility hubs. A mobility hub can be a small neighbourhood hub or a large hub at a train station, with different services and features: 1. Shared modes (bike, scooter, car) and public transport (bus, tram, metro, train) within walking distance 2. Digital display with live information and signage for all modes 3. An attractive hub design (with landscaping features (benches, art, green) and services (cafe, information kiosk, parcel locker) 4. An integrated mobile application for planning, booking and paying different transport modes	Q5→ Belgium

<table>
<tr><td></td><td colspan="3">

Example from Belgium:


</td><td></td></tr>
<tr><td>Q49</td><td>Have you ever seen a mobility hub during your daily trips in [Q5]?</td><td>Select one</td><td>○ No
○ Yes
○ I'm not sure</td><td></td></tr>
<tr><td>Q50</td><td>Have you ever used a mode of transport at a mobility hub in [Q5]?</td><td>Select one</td><td>○ No
○ Yes
○ I'm not sure</td><td>Q49→Yes</td></tr>
<tr><td>Q52</td><td>You have indicated that you travel by public transport and/or shared modes.</td><td>Matrix table</td><td><table>
<tr><th></th><th>None</th><th>A few</th><th>About half of them</th><th>Most of them</th><th>All</th></tr>
<tr><td>Bus, tram, metro</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Train</td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td><td>Q50→Yes
Q39

* Q5→ NOT NL</td></tr>
</table>

	How many of your trips with these modes of transport started or ended at a mobility hub?		*Shared e-scooter						
			Shared bike/e-bike						
			Shared moped/motorcycle						
			Shared car as driver or passenger						
Q154	Out of all the mobility hubs trips that you conducted by **shared e-scooter**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All	Q50→Yes AND Q52 → shared e-scooter
			To/from Work						
			To/from Education						
			To/from Shopping						
			To/from Leisure						
Q156	Out of all the mobility hubs trips that you conducted by **shared car**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All	Q50→Yes AND Q52 → shared car
			To/from Work						
			To/from Education						
			To/from Shopping						
			To/from Leisure						
Q157	Out of all the mobility hubs trips that you conducted by **shared bike/e-bike**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All	Q50→Yes AND Q52 → shared bike/e-bike
			To/from Work						
			To/from Education						
			To/from Shopping						
			To/from Leisure						
	Out of all the mobility hubs trips that you conducted by **shared scooter/motorcycle**, how many were for each trip purpose?	Matrix table		None	A few	About half of them	Most of them	All	Q50→Yes AND Q52 → shared scooter/motorcycle
			To/from Work						
			To/from Education						
			To/from Shopping						
			To/from Leisure						

<table>
<tr><td>Q59</td><td>How likely is it that you will use the modes below in case they are present at mobility hubs in your area in the future?</td><td>Matrix table</td><td>
<table>
<tr><th></th><th>Very unlikely</th><th>Unlikely</th><th>Neutral</th><th>Likely</th><th>Very likely</th></tr>
<tr><td>Shared car</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>*Shared e-scooter</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared bike</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared e-bike</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared cargo bike</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Shared e-moped</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>Q62222</td><td>Which characteristics of a mobility hub are the most important for you?</td><td>Matrix table</td><td>
<table>
<tr><th></th><th>Extremely unimportant</th><th>Unimportant</th><th>Neutral</th><th>Important</th><th>Extremely important</th></tr>
<tr><td>Different shared mobility options</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Availability of different services</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>An attractive design</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Information (digital display, signage)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>One mobile app to plan, book and pay for using different modes of transport</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>Q66</td><td>Latest mobility hub trip</td><td>Side by side</td><td>
<table>
<tr><th></th><th>Mode of transport</th><th>Trip duration</th></tr>
<tr><td>1st mode</td><td>(drop-down list)</td><td>(drop-down list)</td></tr>
</table>
</td><td>Q50→yes</td></tr>
</table>

	Please provide information on your most recent trip during which you used any mode(s) of a mobility hub. Modes of transports Select all the modes that you used across your trip in the order that you used them. In case you used only a single mode, fill in only the information on the 1st mode. Note: walking is also considered a separate mode of transport		2nd mode 3rd mode 4th mode 5th mode Modes of transport: own bike, own car, shared bike, shared e-scooter, shared car, public transport, walking, other Trip duration: up to 10min, 11-20min, More than 20min	
Q92	In case that the shared modes were not available for your latest trip, which mode(s) could you have used alternatively to conduct the trip? Select all that apply	Multiple choice	☐ Own bike ☐ Own car ☐ Own e-scooter ☐ Walking ☐ Public transport ☐ Could not have conducted the trip ☐ Other, specify:	Q66

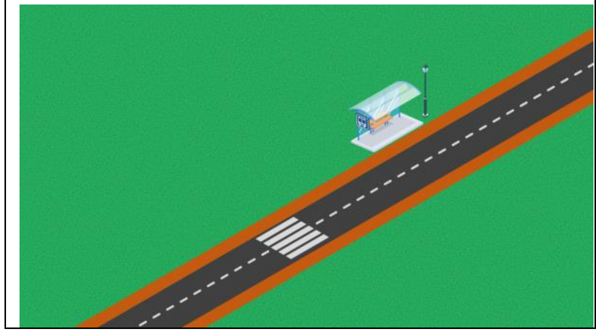
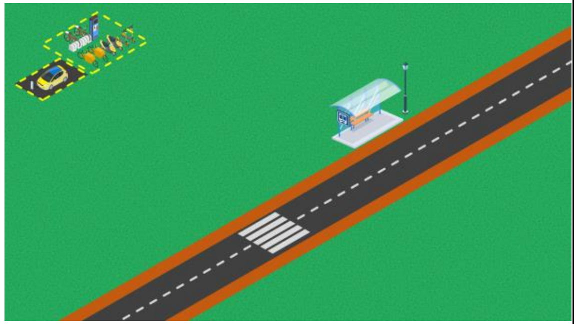
6. Democratic Integration				
ID	Question	Answer Type	Answer set	Routing
Dem1	Have you ever been involved in plans to improve mobility offers in your neighbourhood?	Select one	○ Never ○ Yes	
Dem2	What best describes your participation?	Select one	○ Got information in a workshop/public hearing ○ Got information on a proposal and provided feedback on it in a workshop/survey ○ Proposed solutions to a specific problem in a workshop/similar event ○ Collectively identified issue(s) and proposed solutions ○ Ongoing cooperation to identify issue(s) and develop solutions ○ Other type of participation process	Dem1→Yes

Dem3	How was your input/participation valued? Select all that apply	Multiple choice	☐ My input wasn't heard ☐ My input was valued ☐ I received feedback on how my input was used ☐ I still participate in an ongoing cooperation/network of citizens	Dem2
Dem4	How would you like to participate in decision-making to improve the mobility offers in your neighbourhood in the future? Select all that apply	Multiple choice	☐ Get information in a workshop/public hearing without providing input ☐ Get information on a proposal and provide feedback on it in a workshop/survey ☐ Propose solution(s) to a specific problem in a workshop./similar event ☐ Cooperate to identify issue(s) and develop solutions ☐ Cooperate to identify issue(s) and develop solutions regularly ☐ Other type of participation process ☐ I do not wish to participate in any process in the future	
Dem5	And at which planning phase(s)?	Multiple choice	☐ Working together on a solution for a specific issue ☐ Working together on a proposal for a new overall planning strategy ☐ Feedback to a plan of a responsible organization e.g. municipality, mobility provider ☐ Other planning phase (please specify)	Dem 4→ I do not wish to participate in any process in the future IS NOT SELECTED

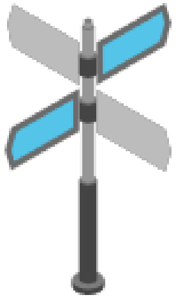
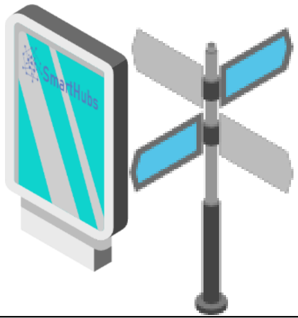
7. Stated Preference Experiment – Hub Design

ID	Question	Answer Type	Answer set	Routing
SP_UT Intro	In this part of the survey, we are interested in understanding your preferences for different elements of mobility hubs. Please analyse the figures below carefully. We consider 5 hub elements, each varying according to 3 levels:			

1. Modes available

Level 1: public transport stop only (shared modes are all scattered and not within walking distance)	Level 2: shared modes are placed together, but not within walking distance from public transport stop	Level 3: public transport stop and shared modes at walking distance
		

2. Information

Level 1: no signage, no digital display	Level 2: signage for all modes	Level 3: digital display and signage for all modes
		

3. Design

Level 1: no landscaping, no services	Level 2: landscaping (green, benches, art)	Level 3: services (cafe, package locker, information kiosk)
		

4. Mobile app

Level 1: No integration between the modes	Level 2: modes are integrated for trip planning	Level 3: modes are fully integrated for trip planning, booking and payment
		

5. Cost

Level 1: No increase in monthly municipal taxes	Level 2: 5 euros per month extra in municipal taxes	Level 3: 10 euros per month extra in municipal taxes
€ 0	€ 5	€ 10

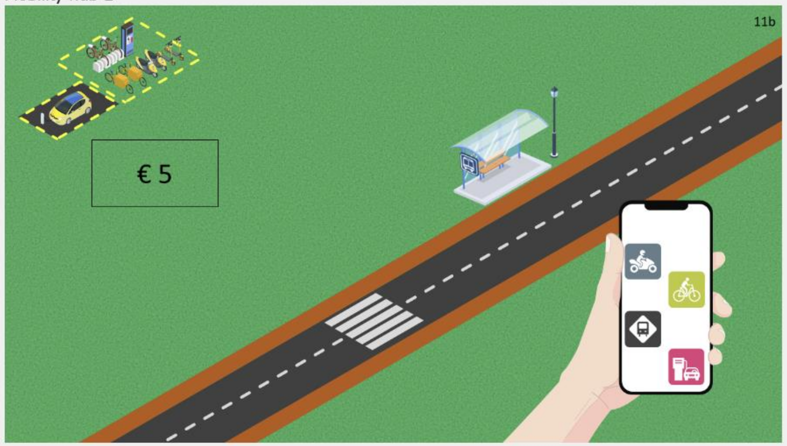
The following 6 questions will show you two hypothetical mobility hubs. You are asked to choose one that best represents your preferences.

<table>
<tr><th>ID</th><th>Question</th><th>Answer Type</th><th>Answer set</th><th>Selection criteria</th></tr>
<tr><td>CS11 (EXAMPLE)</td><td>The table shows two mobility hubs with different characteristics and represented (below) as figures.
<table>
<tr><td></td><td>Mobility hub 1</td><td>Mobility hub 2</td></tr>
<tr><td>Modes available</td><td>shared modes are placed together, but not within walking distance from public transport stop</td><td>shared modes are placed together, but not within walking distance from public transport stop</td></tr>
<tr><td>Information</td><td>signage for all modes</td><td>no signage, no digital display</td></tr>
<tr><td>Design</td><td>landscaping (green, benches, art)</td><td>no landscaping, no services</td></tr>
<tr><td>Mobile App</td><td>modes are integrated for trip planning</td><td>no integration between the modes</td></tr>
<tr><td>Costs</td><td>5 euros per month extra in municipal taxes</td><td>5 euros per month extra in municipal taxes</td></tr>
</table></td><td>Select one</td><td>○ Mobility hub 1
○ Mobility hub 2
○ None</td><td>A random selection of 6 out of 36 CS (choice sets) per respondent.</td></tr>
</table>

Which mobility hub would you choose?

○ Mobility hub 1

○ Mobility hub 2



○ None of these

8. Stated Preference Experiment – Mode Choice (BOKU)				
ID	Question	Answer Type	Answer set	Routing
Ref1	In the next questions please provide some information on the latest trip you conducted by one of the following modes. The trip that you consider should have been between 500 meter (0.5km) and 10000 meter (10 km): - Own car (driver or passenger), - Own bike - Public transport - Walking			
Ref2	Mode of transport?	Select one	○ Own car (driver or passenger) ○ Own bike ○ Public transport Walking	
Ref3	Main trip purpose?	Select one	○ From/to work ○ From/to education ○ From/to shopping ○ From/to leisure	
Ref4	How long was your trip, in meters? For example, 1km=1000meters.	Numeric text input		
Ref5	How many minutes did you walk to reach the **public transport stop**? Please fill in **only the rounded number of minutes**, for example 9.	Numeric text input		Ref2→ Public transport
Ref11	How did you pay for your trip?	Select one	○ I bought a ticket for this trip. ○ I payed via a subscription such as an annual/monthly card or similar.	Ref2→ Public transport

Ref6	Total trip cost (in Euros)?	Numeric text input		Ref2→ Public transport and Ref11→ I bought a ticket for this trip.
Ref8	How many minutes did you wait at the public transport stop? Please fill in **only the rounded number of minutes**, for example 5	Numeric text input		Ref2→ Public transport
Ref9	How many minutes did you walk to reach your **own car**? Please fill in **only the rounded number of minutes**, for example 9.	Numeric text input		Ref2→ Own car
Ref7	Which of the following best describe the circumstances of your trip? Select all that apply	Multiple choice	○ Travelling alone ○ Travelling with a child/children ○ Travelling with at least one more adult ○ Great weather conditions ○ Unpleasant weather conditions	
SPint	In the next 6 questions, we ask you to answer what mode would you choose under different hypothetical scenarios. The scenarios vary in terms of transport modes available for you and the characteristics of these modes (travel time, waiting time, access time, cost, payment method). For all scenarios, imagine a trip in the future that will be similar to the trip you just described: A trip • From/to Work • Travelling alone In total, you will face six(6) different scenarios.			
ID	Question	Answer Type	Answer set	Selection criteria

<table>
<tr>
<td>SPcar1_1 (Choice task example for country of residence: Austria, Germany, or Belgium. In case of location in the Netherlands, instead of an e-scooter, an e-moped was presented.)</td>
<td>
New scenario!

For your trip, you can choose any of the modes below. They are all available for you to travel by. Make sure you check the time (minutes), cost (€), and payment method values before you decide which transport mode you prefer for this new trip.

<table>
<tr><td></td><td colspan="3">Shared modes</td><td></td><td></td></tr>
<tr><td></td><td>Bike</td><td>Car</td><td>E-scooter</td><td>Public transport</td><td>Own Car</td></tr>
<tr><td>Travel time</td><td>27 min</td><td>12 min</td><td>24 min</td><td>16 min</td><td>12 min</td></tr>
<tr><td>Walking time to the vehicle</td><td>3.5 min</td><td>3.5 min</td><td>3.5 min</td><td>3.5 min</td><td>2 min</td></tr>
<tr><td>Waiting time for the vehicle</td><td>1.5 min</td><td>3 min</td><td>0 min</td><td>1 min</td><td>-</td></tr>
<tr><td>Cost</td><td>0.9 €</td><td>2.3 €</td><td>4.8 €</td><td>1.2 €</td><td>5.5 €</td></tr>
<tr><td>Payment only via a mobile app</td><td>No</td><td>Yes</td><td>No</td><td>No</td><td>-</td></tr>
</table>

Which transport mode do you prefer in this scenario?

○ Shared bike
○ Shared car
○ Shared e-scooter
○ Public transport
○ Own Car
</td>
<td>Select one</td>
<td>○ Shared bike
○ Shared car
○ Shared e-scooter
○ Public transport
○ Own car</td>
<td>1) Based on the mode in Ref1, people are assigned to one out of three sets of blocks. The first set is for reference trips by walking or by own bike, the second and third are for reference trips by public transport and own car, respectively.

2) A random selection of one block out of 12 available blocks in the assigned set. Each block consists of 6 choice tasks/questions.</td>
</tr>
</table>

Thank you for completing the SmartHubs survey!
If you want to know more about our project, please visit the SmartHubs project website or if you have any questions or comments regarding the survey, you can email us at smarthubs@boku.ac.at
If you are interested in receiving news about our results or taking part in future mobility surveys, please add your email address below.