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Intention to use neighborhood mobility hubs

Identifying user groups using a Latent Class Cluster Analysis

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Witteveen + Bos

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Master thesis report

by

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Preface

This thesis, with the title *Intention to use neighborhood mobility hubs - identifying user groups using a Latent Class Cluster Analysis*, is the final product of my graduation project that started six months ago. It is the last step in obtaining my Master's degree in Transport, Infrastructure and Logistics at Delft University of Technology.

When starting my studying career with a bachelor in Industrial Engineering in Eindhoven, I never thought that I would end up in Delft. Fortunately, it was a good decision because I completely rediscovered the joy of studying. All my life I have been fascinated by airplanes, so choosing a topic for my thesis would be simple. Given the unfortunate side effect of COVID-19 that all airplanes were parked on the runways, my dream of writing a thesis in the field of aviation was short-lived. Luckily, during my master's, I attained a broader view on transport with a great interest in innovations. So, I approached Niels van Oort for an exploratory conversation about my graduation project. I wanted to do "something with innovation in the transport domain". After this conversation with Niels, I was immediately drawn to the (future) "holy grail" of the sharing economy: mobility hubs. And here we are now: after 119 pages and numerous new insights, this really is the end of my study period.

I would like to thank Witteveen + Bos for the opportunity to perform this research at the company. I also would like to thank my company supervisor Tessa Leferink in particular for her endless positivity, helpful advice, numerous readings of my texts and of course the fun during my graduation period. Moreover, I would like to thank the team of Witteveen + Bos for making me feel welcome in each of the offices and for providing a pleasant distraction from the (kind of) lonely process of graduation.

Furthermore, I'd like to thank my TU Delft supervisors, Jan Anne Annema, Niels van Oort and Nejc Geržinič, for their valuable advice, feedback and time. Jan Anne Annema was the most encouraging and positive supervisor a student could ask for ("Don't worry, it's only a master's thesis") and many thanks to Niels van Oort who introduced me to Witteveen + Bos and his valuable knowledge in both science and practice. Necj Geržinič, thank you for the feedback sessions and your knowledge about the many statistical methods available in the scientific world. Also a big thank you to Bert van Wee for offering such extensive feedback at the official supervision meetings. Finally, I would like to thank my parents and girlfriend Annemarie for their endless trust, love and support.

R.O. (Ralph) van der Meer
Leiden, August 2022

Summary

Over the past decades, car ownership in the Netherlands has been on an increase. Meanwhile, passenger cars are a pressing environmental burden, as it causes 58% of the CO_2 emissions of the transportation sector. Also, the car requires a lot of space on the street (compared to other modes of transport) even though it remains parked 90% of the time. To address these issues, offering shared mobility might lead to a solution in reducing car ownership. An important trend is the development of new means and forms of shared transport, in which a neighborhood mobility hub might play an important role in. A neighborhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations which are available at walking distance from home. A connection with public transport as well as other types of services (mobility and non-mobility related) is possible but not required. With neighborhood mobility hubs, car ownership may be reduced by providing beneficial features for the end user such as (1) increased mobility, (2) accessibility and (3) flexibility without negative aspects as (1) space use and (2) high emissions.

As a relatively new concept, mobility hubs are starting to gain attention in academia and practice. However, the focus is mainly on medium-sized to large mobility hubs (such as train stations and park and rides) which are located in urban areas or at the edge of cities. Moreover, the first findings showed that the adoption rate of mobility hubs might be low. The success of a mobility hub depends mainly on the usage of the traveler. Because the literature into neighborhoods mobility hubs are an ongoing process, no good image of the user can be formed. A new user orientated approach is thus needed in order to contribute to a better adoption of the mobility hub. This research aims to contribute to that by identifying *which user groups are likely to adopt mobility offered by neighborhood mobility hubs in the Netherlands.* Furthermore, some sub questions are used in the study:

1. What is a neighborhood mobility hub and what functionalities does it have?
2. According to literature, which factors are associated with the intention to use mobility offered by neighborhood mobility hubs?
3. Which user clusters can be identified and what effects do these clusters have on car ownership?
4. What is the relation between users' current mobility pattern and the intention to use neighborhood mobility hubs?

In order to discover people's intention to use neighborhood mobility hubs, technology adoption models have been considered. The UTAUT2 model was found to be the most suitable model to discover the behavioral intention to use mobility offered at mobility hubs. The UTAUT2 model is based on eight proven technology acceptance models, has a focus on consumer technologies and is known for its high prediction accuracy. With the use of literature, the following factors were expected to influence the behavioral intention to use mobility offered at neighborhood mobility hubs: performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, environmental concern and individual innovation.

The conceptual model was complemented with moderators so that more information could be gathered related to the user characteristics. A questionnaire (N=298) was distributed to gather data among Dutch citizens. The majority of the respondents were collected using online channels, some of the respondents were approached on the streets of the Hague, Leiden and Utrecht. The survey mainly consisted of closed-end questions, which could be answered using multiple choice and likert-scales. Besides questions related to the conceptual model, the questionnaire was used to gain insights in the socio-demographical characteristics of the respondents, their current mobility pattern, whether they had prior experience with shared transport and further questions regarding their intention to use mobility hubs in the future.

The general findings indicate that respondents' intention to use neighborhood mobility hubs are considerably high: 48.6% of the sample assumes to use a mobility hub when it is available in their neighborhood. When assuming a maximum walking time of 5 minutes towards a hub, even 64.5% intends to use it. Of the sample population, 21.4% states that they intend to use their car less often when a mobility hub is present in their neighborhood. The effect on car ownership is slightly lower: 8% expects to sell their households' sole car, while 14.8% thinks that they will sell their second or third owned car.

Regarding the respondents' intentions to use one of the various modes of transport offered at a hub, the shared car is the most preferred, followed by the shared moped and shared e-bike. The shared bicycle is found to be

the least preferred mode of transport, probably because many Dutch people have a bicycle at home. When looking at the different age groups, the shared moped is mainly popular in the age group 18-25 years old and the shared e-bike is a popular mode of travel in the age group 65+. Moreover, the general findings indicate that people living in urban areas intend to use shared mobility more often compared to the people living in little-urban or non-urban areas. Concerning the difference in intention to use shared transport for men and women, it appears that women have a higher intention of using hubs for each mode of transport. This is a surprising finding compared to prior studies.

The data was further analyzed using an Exploratory Factor Analysis (EFA) to better understand the underlying structure of the variables, to reduce the data set and to prepare the data for executing a Latent Class Cluster Analysis (LCCA). The EFA resulted in four remaining factors: mobility hub beneficials (combination of the indicators performance expectancy, effort expectancy and hedonic motivation), facilitating conditions, individual innovation scepticism and social-environmental responsibility (combination of the indicators social influence and environmental concern). Together with a fifth factor, to measure the behavioral intention to use neighborhood mobility hubs, these factors were used in a Latent Class Cluster Analysis. The LCCA segments the sample population in different groups (or: clusters) with similar preferences and socio-economic profiles. For this study, a four-cluster model was found to be the most preferred. A description of the different clusters as well as a visualization of the important user characteristics per cluster (Figure 1) can be found below.

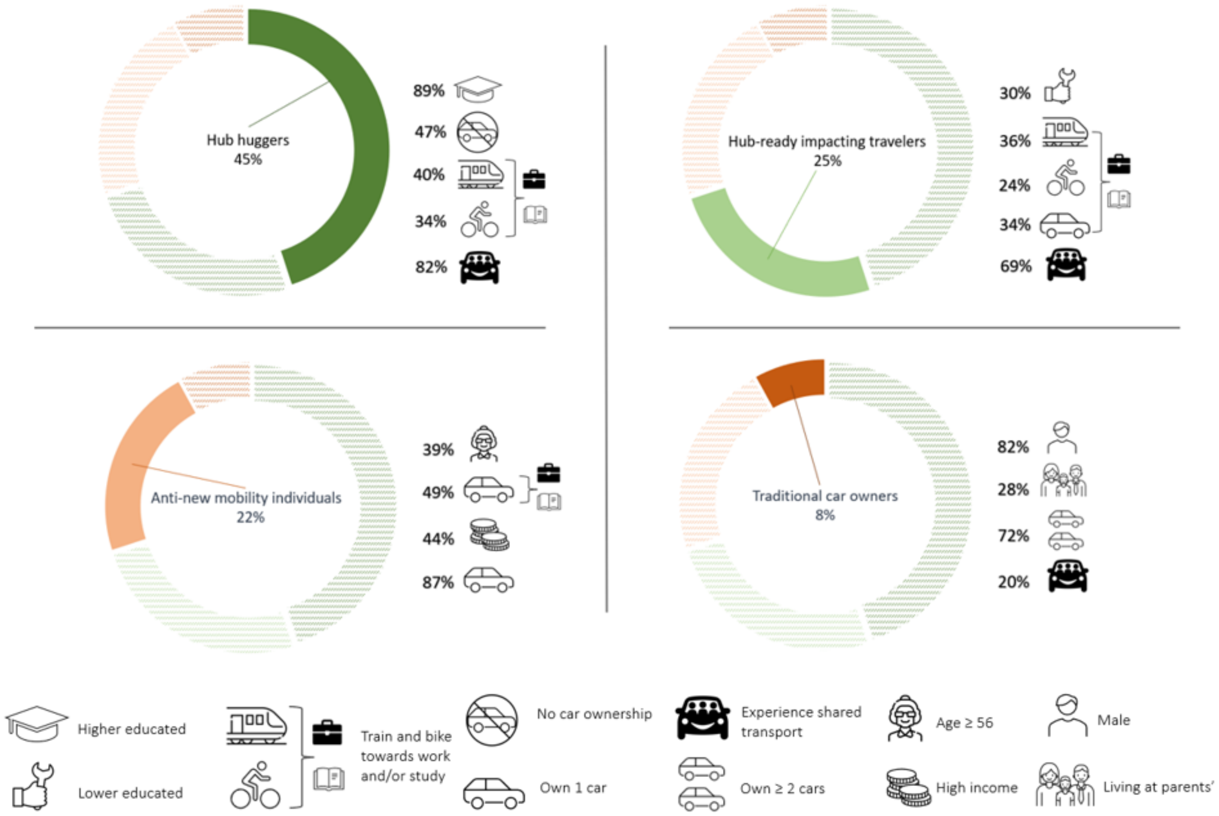

Figure 1: Visualisation of the clusters and most important covariates

Hub huggers - 45% of the sample

The *hub huggers* have the highest intention to use mobility hubs in the future, with the highest scores for all indicators (resp. lowest score for facilitating conditions), indicating that the intention to use neighborhood mobility hubs is high. The cluster consists of relatively young people (<35 years old) who have had a higher education (89%). The majority of the sample has a job (full-time or part-time) or is still studying. The latter probably justifies why 47% of the sample does not own a car. Of the sample, 82% has used shared transport in the past and the current travel behavior towards work and/or study is mainly done by train or (e-)bike. The possible effect of a future hub on car usage and car ownership is not the highest among all clusters, but still relatively high: 25% of the cluster members indicate that they would use their car less when a hub is present, 17% would sell their second car in the household and 9% would sell their only car.

Hub-ready impacting travelers - 25% of the sample
Members of this cluster also have relatively high indicator scores, but still need some guidance when making reservations and/or paying with their phone. Of the cluster members, 30% has a low level of education. 36% of the cluster households doesn't own a car, the remaining members own at least one car per household. Regarding travel behavior towards work and/or study: 34% uses their car, 24% goes by (e-)bike and 36% takes the train. The share of people who already have used shared transport is also quite high: 69%. Due to the presence of a mobility hub, 29% of the cluster expects to use their car less often, 20% expects to sell their second car and 11% expects to sell their only car, which is the highest among all clusters. Therefor, in comparison, this cluster will have the greatest impact in terms of car use and ownership. This may be due to the lower share of students and a higher percentage of more than two cars per household.

Anti-new mobility individuals - 22% of the sample
This cluster consists of cluster members which are not (yet) willing to use hubs in the future, characterized by the lowest score for facilitating conditions meaning that the people in this cluster have the most difficulty using their mobile phone. The cluster contains all age groups, with a relative higher share (39%) of individuals older than 56. The scepticism of using new technologies paired with the higher share of older people who do not intend to change their travel behavior in the future, result in the typical anti-new mobility individual. The cluster consists of households who live on a varying level of urbanity and of which 87% has minimal one car. This also explains the high car percentage (49%) to travel to work and/or study. Of these cluster members, 44% have a high households' income of > 50.000 euros/year. The people in this cluster have little interest in changing their travel behavior, since 64% thinks that a mobility hub will not change their car usage in the future. In addition, 9% of the 'anti-new mobility individuals' think that the presence of a hub ensures that their second car is sold and 6 percent think that their only car will be sold.

Traditional car owners - 8% of the sample
The behavioral intention to use hubs as well as the mobility hub beneficials are the lowest among all clusters. This means that the members of the cluster have little urge to make use of mobility hubs in the future. The cluster consists of mainly men (82%) and car ownership is high: 92% of the households have at least one car, 72% own two cars or more. Furthermore, the majority of the cluster has no prior experience with shared mobility. Besides the car (36%), the (e-)bike is also a popular mode of travel towards work or study (36%), this may be explained by the share of people (28%) who live at their parents' house and possibly use their (e-)bike to school. The effect on car usage and ownership is very limited: 71% of the members in the cluster think that the presence of a mobility hub in their neighborhood would not affect their car usage in the future. They would still make use of their car; no person would sell their only car in the household, 4% would sell their second car.

Looking at the results of the LCCA, it can be concluded that two of the four clusters have an intention of using neighborhood mobility hubs. Among these clusters, there is a difference in the effect on car ownership. The main difference with the *hub huggers* is that the *hub-ready impacting travelers* consist of a lower share of students (resp. higher incomes and age) and consequently a higher share of two cars (or more) per household. Moreover, cluster members of *hub-ready impacting travelers* live in a lower degree of urbanity. This makes that the potential impact on car ownership is higher among members of *hub-ready impacting travelers*.

There are some determinants that are likely to play a role in future mobility hub usage. The findings discussed above show that people with prior experience with shared transport are more likely to use neighborhood mobility hubs in the future. Moreover, clusters that intend to use hubs have a higher share of households who do *not* own a car. Persons who currently use a sustainable travel mode (train or (e-)bike) to reach their work and/or study are more likely to be the adapters of neighborhood mobility hubs. This also holds for people that have a social and environmental responsibility, innovative mindset and clearly see the benefits of using a mobility hub and which are (most often) higher educated and younger of age.

The findings of this study indicate that a successful uptake of a neighborhood mobility hub seems realistic for many people and is expected to be a potential change maker for urban mobility. This research also entails some limitations and recommendations. A limiting factor in this research is that the sample of respondents is not fully representative of the Dutch population, due to the majority of young people, males and higher educated people living in higher density areas. This may result in an overestimation of the intention to use mobility hubs. It is therefore recommended to follow up this study with a more representative sample. Moreover, this study employed 'behavioral intention' as dependent variable in the conceptual model instead of 'use behavior'. This makes this research a stated preference study, what could have resulted in an overrepresentative group of members which intend to use hubs. This is not unusual for this exploratory phase in the study into mobility hubs. However it is recommended that further studies employ a revealed preference study based on the actual usage of mobility hub users. This would also create the opportunity to add price value as an indicator. As a result, the bias will disappear and more realistic findings could occur. A small side note here is that the sample size needs to be large enough, which might be difficult given the (still) small amount of mobility hubs in the Netherlands. Regarding recommendations for practice it is advised to start developing neighborhood mobility hubs in inner-city neighborhoods. These areas contribute to a number of factors that are positively associated with the intention of using hubs, such as a maximum of five minutes walking time towards a hub, that potential hub users live in dense environments and ideally do not own a car. Moreover, when developing a mobility hub, a demographic scan of different neighborhoods is recommended which should be compared with the (cluster) demographics of this research. This might help with finding suitable neighborhoods in which mobility hubs could potentially be used. When a mobility hub is actually implemented in a neighborhood, it is advised to actively encourage its usage by bringing (media) attention and discounts. Furthermore, local governments can use push factors to encourage hub usage by residents, such as car-free zones and higher parking fees in the neighborhood.

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1 Introduction

1.1 Context

For years, the car has been a popular mode of transport: since 1990, car ownership has increased from 0.8 to almost 1.1 cars per household (KiM, 2022b). In 2020, 8.7 million passenger cars were registered in the Netherlands, accounting for a distance of 122.5 billion kilometers traveled (CBS, 2019). Moreover, in 2019 49% of the total trips were made by passenger cars in the Netherlands (CBS, 2020b). The transport sector as a whole contributes to climate change by being one of the largest sources of greenhouse gas emissions. Despite the fact that more and more electrical cars are introduced on the road, the total amount of CO_2 emissions of the transport sector is 28.50 million kilograms in 2018, of which 58% is caused by passenger cars (CBS, 2021b). Due to the Paris agreements, the transport sector needs to reduce their CO2 emissions by 60% in 2050 compared to 1990 (Ministerie van Economische Zaken, 2016).

Passenger cars are not only an environmental burden but they also require a lot of space compared to other modes of transport, such as cycling and public transport (PT) (Natuur en Milieu, 2020). Since cars are generally parked for more than 90% of the time, a large number of motorized vehicles require a considerable amount of parking space (KiM, 2018b). To illustrate this, Figure 2 shows the use of space for various means of transport. It shows a considerable dominance of the (moving) car. Parked cars and bicycles combined occupy a large amount of public space, which can potentially also be used for public green spaces, housing or recreation. It is clear that mitigating the impact of passenger cars on climate change and public space requires a shift to a more sustainable view of transport.

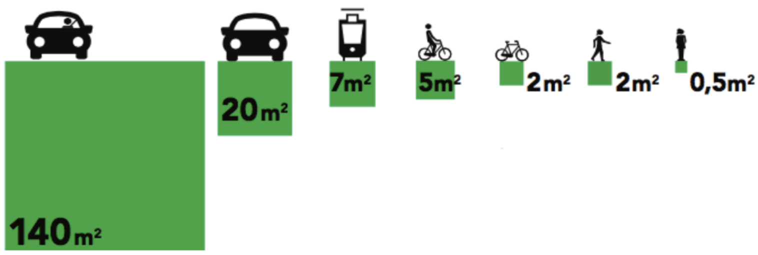


Figure 2: Space per means of transportation, retrieved from Gemeente Amsterdam (n.d.-b)

In Dutch cities, long-term strategies are developed to reduce driving and parked cars and improving public space with cleaner and more active travel (Gemeente Amsterdam, 2019). An important trend is the development of new means and forms of shared transport, in which the mobility hub plays an important role. In their most basic form, mobility hubs are physical places where a user can transfer from one mode to another (KiM, 2021c). The idea of a mobility hub is not a new concept, however its use is changing over the years. In the past, a mobility hub was a location where you arrived and parked your car and switched to public transport, such as a Park and Ride (Rijkswaterstaat, 2020). Today's mobility hubs fulfill the function of an exchange place where different and connected (shared) transport modes, such as PT, electric bicycles, electric cars and electric scooters can be offered (CoMoUK, 2019; KiM, 2021c; Knaack, 2021). It is not only a place where public and shared mobility modes are brought together, but also a place of activity (e.g. parcel lockers, shops) for the neighborhood. For this reason, more and more cities are developing mobility hubs, as they not only want to promote the use of sustainable transport but also serve as an enrichment of public space (CoMoUK, 2019).

1.2 Research problem

In recent years, the concept of a mobility hub has attracted a lot of attention in the academic world. In published research, the focus is mainly on medium to large mobility hubs that are located in urban areas or at the edge of cities (KiM, 2021c; Rijkswaterstaat, 2020). Less scientific research is available for the smaller type of hubs, also known as the neighborhood mobility hub. A neighborhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations which are available at walking distance from home. A connection with PT as well as other types of services (mobility and non-mobility related) is possible but not required (see literature section 3.1.1 for full explanation). These neighborhood hubs are of great significance for solving mobility problems of neighborhoods using sustainable transport. In this way, personal car use may be reduced by providing beneficial features (e.g. increased mobility, accessibility, flexibility) without the negative aspects (e.g. space use, high emissions, congestion) (Knaack, 2021).

At more and more places in the Netherlands, neighborhood mobility hubs are being developed. Some of these hubs are initiated by the government as pilots but the majority is initiated by companies such as Hely or Mobipunt. The results of these pilot studies have not been published widely. Therefore, research on neighborhood mobility hubs is expanding mainly due to theses. The research of Franken (2021) executed a stated choice experiment in order to find out if there is a willingness to use shared mobility offered by a hub instead of a private car. In the short term, travellers are willing to use the shared e-car especially for travelling to work. For longer distances (22.5 km - 75 km), there is even more preference for the shared e-car in relation to the private vehicle. Dependent on the area they lived in they would even give up their own least used car. This stated choice experiment shows that the future of mobility hubs is quite positive. The study of Van Rooij (2020) into neighborhood mobility hubs and their users' travel behaviour indicated that only 20% of the residents *actually* used the hub. In total 11% of the users had actually decreased their car ownership and the majority of the users (75%) used the shared car when making a trip. These results are less positive than the findings of Franken (2021) but it must be noticed that the results of the study of Franken (2021) are stated choice results and therefore not based on actual mode choice and experience.

Since the outcomes of Franken (2021) and Van Rooij (2020) are somewhat contradictory and no further research is found on neighborhood mobility hubs, a closer look should be taken into studies examining multiple forms of shared mobility. Karlsson, Eckhardt, Sochor, Aapaoja, and König (2017) conducted a shared mobility experiment in Vienna: only 6% of the residents made daily use of shared mobility, and 30% of the residents used it on a weekly basis (Karlsson et al., 2017). The usage in the Netherlands is somewhat lower: 2-6% of the Dutch population have used a shared car in the period 2018-2021 KiM (2021b). Moreover, 10% of the population have used a shared bicycle, of which 2% of the population uses it regularly KiM (2021b). Except for the stated choice experiment of Franken (2021), an early conclusion of the above mentioned research is that the willingness to use shared mobility and mobility hubs might be low.

There are a couple of reason why the adoption rate is low. First of all, costs are an important barrier in starting the use of the mobility of a hub (Knippenberg, 2019). Moreover, residents did not know the hub existed, there was no parking pressure and distance to the hub was too large (Franken, 2021; Van Rooij, 2020).
However, the success of a mobility hub as a means for reducing emissions depends mainly on the actual usage of the traveller (Franken, 2021; Knippenberg, 2019; Snel, 2020). As indicated above, the adoption rate of shared mobility offered in mobility hubs however is low. In the research available, there is not much known about the user and no consistent image can be formed of the user. The thesis of Van Rooij (2020) shows that the typical user of a neighborhood mobility hub is young, low educated, has a partner and children and no private car access. The research of Knippenberg (2019) also reflects on the typical hub user as young person living in either a two-person household or with kids. Contrary to the research above, the hub user is higher educated and owns at least one private car. Because the literature into neighborhood mobility hubs is scarce, no fixed image of the user can be formed. A new user orientated approach is needed in order to contribute to a better adoption of the mobility hub.

1.3 Research objective & research questions

As argued previously, the development of mobility hub initiatives requires careful consideration of the user perspective. The success of neighborhood mobility hubs depends on the willingness and capacity of travelers to use the services offered to them. The type of user however is unknown (Knippenberg, 2019; Van Rooij, 2020). This research aims at identifying which user groups are likely to adopt mobility offered by neighborhood mobility hubs in the Netherlands.
First of all, the definition and facilities of a neighborhood mobility hub will be explained and a definition will be initiated for the remaining of the report. Secondly, a literature study is done on the indicators influencing the intention to use mobility offered by a neighborhood hub. In order to get a better understanding of the mobility patterns of the user, this study will investigate what the current travel behavior of the sample population is and whether there is a relation with the intention to use neighborhood mobility hubs. Furthermore, user clusters will be identified based on the above mentioned indicators. The focus will not only be on the user groups that have the intention to use mobility hubs. It is also interesting to gain insights into the groups that might not be ready to adopt yet and what are their reasons. The effect of these user clusters on car ownership will also be examined here.

The main research question of this study is:

Which user groups can be identified in adopting mobility offered by neighborhood mobility hubs?

The following sub research questions will be addressed:

1. What is a neighborhood mobility hub and what functionalities does it have?
2. According to literature, which factors are associated with the intention to use mobility offered by neighborhood mobility hubs?
3. What is the relation between users' current mobility pattern and the intention to use neighborhood mobility hubs?
4. Which user clusters can be identified and what effects do these clusters have on car ownership?

1.4 Scope

This research focuses on potential user groups related to neighborhood mobility hubs in the Netherlands. These smaller type of mobility hubs are physical platforms offering multiple forms of shared transport, such as (e-)bikes, e-mopeds and electric cars available at walking distance from home. A more detailed description is given in section 3.

This research will be conducted in the Netherlands. The sample population consists of all people living in the Netherlands having an age of ≥ 18. Neighborhood mobility hubs will mainly occur in urban residential areas and rural areas (section 3.1.1). The physical survey conduction will mainly take place in those areas, however all persons (age ≥ 18) living in the Netherlands are able to participate. The reason to research all potential users, and not just car owners, is to provide a complete picture of the user groups in the Netherlands. There is quite a difference in car ownership per region among young adults (CBS, 2018). In order to keep the study representative, all adults will therefore be able to participate.

1.5 Relevance

The scientific relevance is already largely explained under section 1.2. To sum up, since the amount of literature on mobility hubs is scare, this study contributes on adding knowledge to this field. Moreover, this research contributes to add knowledge about user groups of shared mobility offered by neighborhood mobility hubs, their adoption potential and the effect on car ownership. The study of Molin, Mokhtarian, and Kroesen (2016) indicates that a Latent Class Cluster Analysis has been applied in the transportation domain but the number of applications is rather limited. No other study in the field of mobility hubs used this method before, to the author's knowledge.

The societal relevance contributes to the different user groups that are likely to adopt mobility hubs. In this way, knowledge is gained about these groups, which can be used by practitioners and municipalities to decide on tailor-made measures or policies. In addition, there will be more knowledge about the potential end user, which is relevant for developers of hubs and area development. Eventually, this could lead to a reduction of car ownership which may result in a reduction of CO_2 emissions and a redesign of public space. But above all, an increase in the use of shared mobility contributes to a more sustainable place to live.

1.6 Research structure

The research structure is visualized in Figure 3. This research consists of three main parts: 1) conceptualization, 2) data collection and 3) data analysis and results. To start, in chapter 1 the problem statement, research problem and research questions are discussed.

Conceptualization
In chapter 2, the conceptualization begins with an explanation of the methods used in the research. Furthermore, in chapter 3 the literature review starts with reviewing different topics related to the state-of-the-arts of mobility hubs and their users. Moreover the car ownership in the Netherlands is investigated. What follows is a comprehensive study of the factors that influence the intention to use mobility offered by neighborhood mobility hubs. The result is a conceptual framework which is used to design the Latent Class Cluster Model. When looking at the direction of the arrows in Figure 3, each block of information goes straightly to the design of the survey, but also to the next block of literature. This is done because some of the information about e.g. car ownership is needed when forming the conceptual model.

Data collection
Using the indicators of the conceptual framework, a survey is conducted. In this section, there will be an explanation how the survey is created. The survey will be distributed using social channels and on the streets. More information is given in section 2.

Data analysis and results
In this section, the data of the survey is analyzed. As can be seen in the figure, there are two parts in the results section: 1) socio-demographics and general findings and the 2) Exploratory Factor Analysis (EFA) and Latent Class Cluster Analysis (LCCA). The section starts with the descriptive statistics that are compared with the Dutch population. Subsequently, the general findings of the survey are presented, consisting of the first findings related to potential hub usage and the current travel pattern of the sample population. Then the second part of the analysis starts, where the EFA is executed, after which a LCCA is performed. After these analyses each cluster is described using the moderators. Moreover, the effects of neighborhood hubs on car ownership will be determined per user group. The research is concluded with a conclusion and discussion.

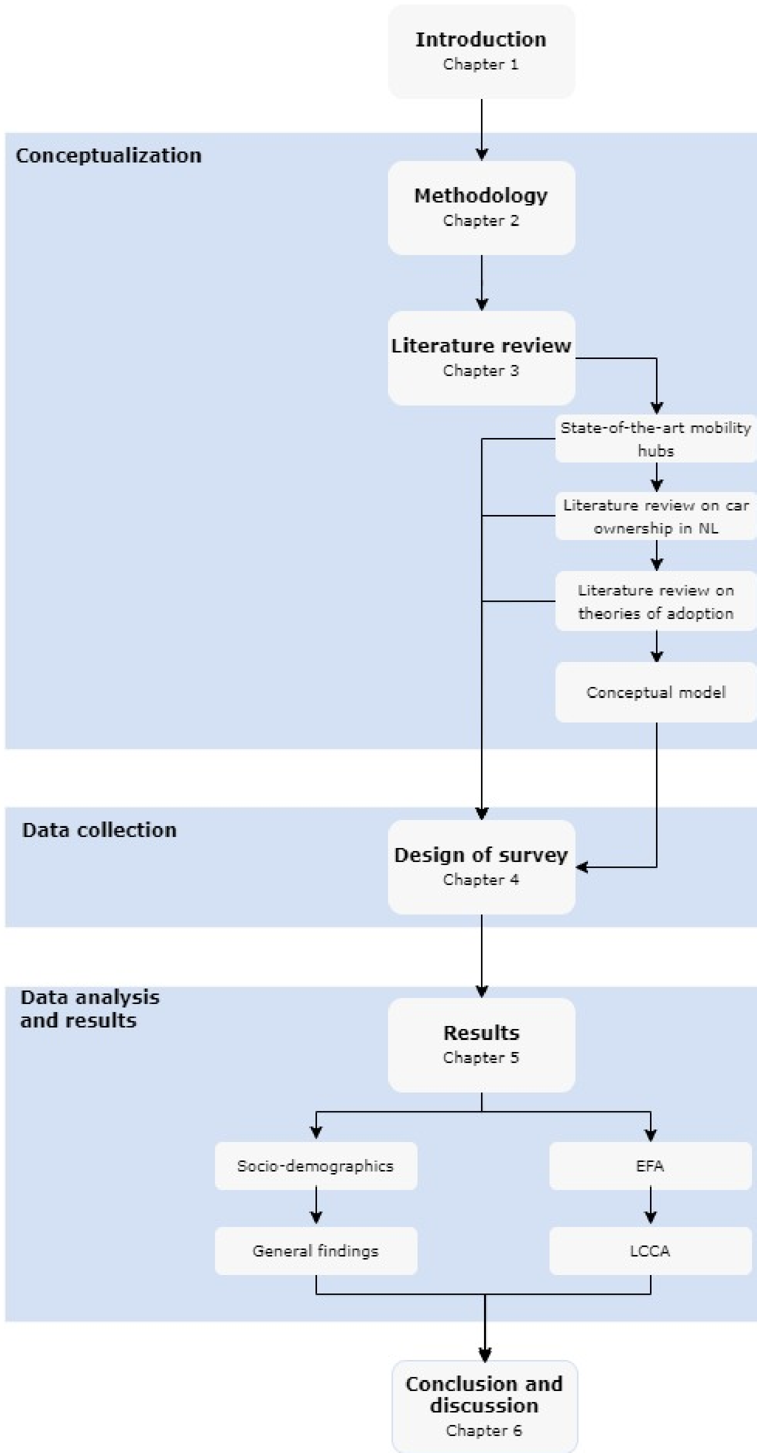


Figure 3: Thesis structure

2 Methodology

In this section, the methodology of this research will be discussed. First, the research questions and proposed methods can be seen in Table 1. In Figure 4 an overview is given of the research process which will be explained properly below.

Table 1: Research questions and proposed methods

RQ: Which user groups are likely to adopt mobility offered by neighborhood mobility hubs?	
Sub research questions:	**Method(s)**
1. What is a neighborhood mobility hub and what functionalities does it have?	Literature review
2. According to literature, which factors are associated with the intention to use mobility offered by neighborhood mobility hubs?	Literature review
3. What is the relation between users' current mobility pattern and the intention to use neighborhood mobility hubs?	General findings, LCCA
4. Which user clusters can be identified and what effect do the decisions of these users have on car ownership?	Literature review, EFA and LCCA

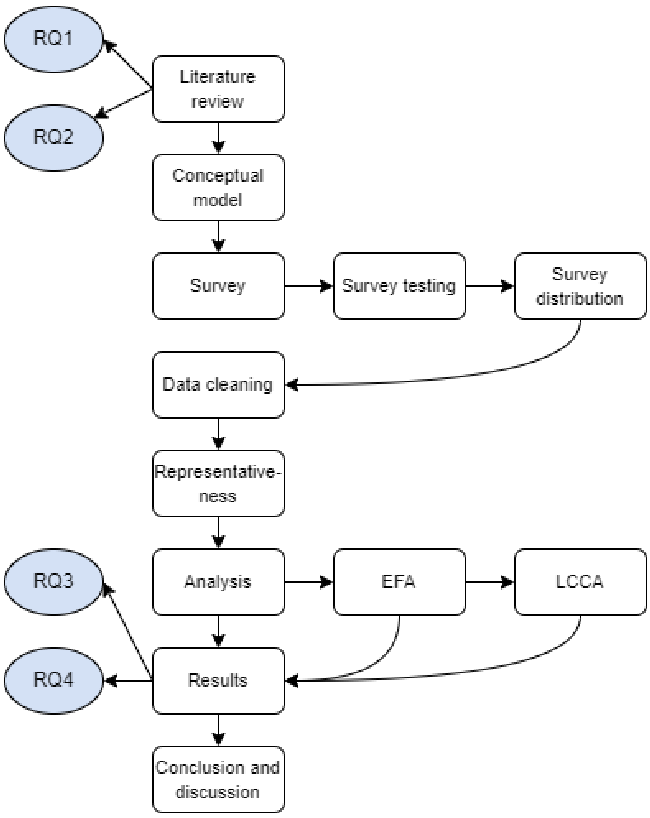


Figure 4: Methodology

2.1 Literature review

The objective of the literature study was to gain insights into mobility hubs in general and neighborhood mobility hub specifically. Moreover, a review was needed on the state-of-the-art regarding car ownership in the Netherlands. Lastly, knowledge needed to be gained about theories of adoption and what factors were relevant for the intention to use mobility offered by the neighborhood hub. These goals were succeeded by searching for scientific literature in combination with grey literature such as theses and company reports. Scientific literature was found using different search engines: Google Scholar, Scopus and Science Direct. Whether an article is useful was based on the year of publication, title, number of citations and the abstract. When an article was perceived as useful, the concept of 'snowballing' was executed. Snowballing refers to using the reference list of a paper or the citations to the paper in order to find more interesting literature regarding mobility hubs. Besides scientific articles, grey literature was needed for this research because there is too little scientific research available on neighborhood mobility hubs. The main research topics for the literature study can be found in Table 2, together with the search terms needed. At the end of the literature study, sub question 1 and sub question 2 were able to be answered.

For sub question 1, a definition of neighborhood mobility hubs needed to be formed. This was done using both scientific and grey literature. Moreover an overview of research into neighborhood mobility hubs was given and a literature review on mobility hub users was executed. Because the number of scientific literature on neighborhood mobility hubs is limited, also the user groups of mobility hubs in general was investigated.

For sub question 2, the starting point was a literature review on adoption theories. An overview was given of the relevant adoption theories regarding technologies and innovations. Hereafter, factors were investigated that might influence the intention to use hubs. Because the concept of hubs is quite new in academic literature, it was decided to broaden the search term regarding the intention to use neighborhood mobility hubs. First, literature was searched in the field of neighborhood mobility hubs and mobility hubs in general. When this search term did not provide enough information, the search term was broadened in the direction of MaaS and shared mobility. Eventually, a conceptual model was formed using the - by literature substantiated - factors.

For sub question 4, a literature review was needed on the state-of-the-art regarding car ownership. The goal was to gain knowledge about car ownership in the Netherlands. A comparison was made in car ownership between European countries. Hereafter, the focus was being shifted towards the Netherlands in order to map out (current and future) developments in car ownership. The literature review can be found in chapter 3.

Table 2: Research subjects and search terms

Research topics	Search terms
Define and categories mobility hubs	"Mobility hub", "Mobility and hub", "Shared mobility hub", "Mobility and hub and shared and transport",
Neighborhood mobility hubs	"Buurthub", "Neighborhood mobility hub", "Neighborhood and mobility and hub", "Mobility hub", "Mobility and hub",
MaaS and hubs	"Mobility as a Service", "MaaS", "MaaS and Mobility and Hubs"
Existing hubs in NL	"Buurthub", "Mobihub", "Mobipunt", "Hely", "eHubs"
Type of mobility offered	"shared mobility", "shared and mobility", "Shared and mobility and mobility and hub", "shared and modalities and mobility and hubs", "MaaS and shared and mobility"
Previous research into hubs regarding intention to use and effect on car ownership	"Buurthub", "Neighborhood mobility hub", "Neighborhood and mobility and hub", "Mobility hub", "Mobility and hub", "Shared mobility hub", "Mobility and hub and shared and transport",
Hub users	"mobility and hubs and user", "mobility and hubs and user characteristics", "MaaS and user", "Shared and mobility and user"
Car ownership in NL	CBS data
Theories on adoption	"Adoption", "Intention to use", "Innovation and adoption" and "Technology and adoption", "Technology Acceptance"
Indicators regarding intention to use hubs	"UTAUT", "UTAUT2", "*name indicator* and UTAUT2",

Conceptual model

As a last part of the literature study, the conceptual model could be created. For this, the literature research is highly important since the quality of the theory determines quality of the model (Maarten Kroesen, 2021). The conceptual model is based on the UTAUT2 model, without the indicator habit and with extra indicators environmental concern and individual innovation added. The UTAUT2 model is very appropriate to use because its an comprehensive technology acceptance model, based on eight other already proven models (Straub, 2009), which may result in explaining up to 74% of variance for BI (highest among all technology acceptance models) (Venkatesh et al., 2012). Moreover, the UTAUT2 model leaves out business oriented determinants and adds determinants in the consumer field, which makes it a good model to investigate individual acceptance and adoption of an innovation (Morrison & Belle, 2020). The underlying theoretical basis and the final conceptual model can be found in chapter 3.4.

2.2 Survey

When the conceptual model was finished, the questionnaire could be created. The design of the questionnaire is explained extensively in chapter 4. Survey research makes use of standardized questionnaires or interviews to collect data about individuals and their preferences and behaviors in a systematic way (Bhattacherjee, 2012). For this research, a questionnaire survey is used because it is seen as a more objective research tool which may produce more generalizable results because of the larger sample size compared to interviews (Harris & Brown, 2010). The questionnaire consists of categorical questions, 5-point Likert scale questions and two open questions.

After the questionnaire was created, a number of pilot versions were tested before the final version was made public. The pilot surveys and the iteration process ensured that the final survey is clear and understandable to all respondents. The pilot survey was completed by a diverse group consisting of some family, friends, graduation committee and colleagues of Witteveen and Bos. In total, 12 persons tested the survey, with an average time of 10 minutes to complete the survey. Main improvements were improvements in terms of more readable paragraphs and clearer questions.

For the survey, a sample size of about 300 respondents is desirable in order for the data analysis to be valuable (Field, 2013). The survey was distributed using the internet and on the streets. The survey was shared using a post on LinkedIn and Facebook. Moreover, the survey was distributed among friends, family colleagues students. Besides, the questionnaire was distributed among employees of Witteveen + Bos. The reason for distribution on the streets is because personal handed-out surveys have a higher response rate (Nulty, 2008). The respondents on the streets were given a flyer with a QR-code on it which they could scan and fill in the survey.

Eventually, the survey was distributed offline in The Hague, Leiden and Utrecht. The respondents of the survey needed to have an age of 18 or older. Persons having an age below 18, are not allowed to drive a car, so are of less interest for this study. These persons are allowed to ride a shared bicycle or ride a moped (age $\geq$ 16), however it is still decided to not let them participate because they are not able to make an account on the current sharing systems. People could participate if they do not own a car. The reason to research all potential users, and not just car owners, is to provide a complete picture of the user groups. Research indicated that persons which might use hubs currently travel using sustainable modes (Bösehans et al., 2021; Knippenberg, 2019). Public transport and cycling belong to this too, which may result in interesting findings when creating users clusters.

Ethical considerations

Certain ethical considerations needed to be taken into account because the survey contained human subjects. First of all, an informed consent was written in the introduction page of the survey, indicating that the participation is completely voluntary and anonymous and that the participant can leave the survey at any time. Moreover, no personal information that could be traced to the individual was asked in order to comply with the GDPR. Before the survey was distributed, permission was requested and granted from the Human Research Ethics Committee (HREC) of the Delft University of Technology. In Appendix E the approval letter of the HREC can be found.

Cleaning data and representativeness of sample

When the survey was closed and enough respondents were gained, the data needed to be cleaned. Respondents that did not fully completed the survey were deleted from the sample, as well as the respondents who have an age of below 18. After cleaning the data, relevant data of the sample regarding socio-economics and car ownership was compared with actual CBS data in order to see whether the sample data is comparable on the Dutch population.

2.3 Exploratory factor analysis

After the data is collected, the data analysis starts. This however does not begin with a LCCA. First, a factor analysis needed to be executed. Factor analysis is a method for modeling observed variables, and their covariance structure, in terms of a smaller number of underlying (unobservable) latent factors (Field, 2009), such as the intention to use mobility hubs. Factor analysis is a technique that can be used to (1) understand the structure of a set of variables and (2) to reduce the data set to a feasible size while keeping as much of the original information (Field, 2009). Moreover, a factor analysis makes it possible to execute a cluster analysis (Kootstra, 2004). There are two types of factor analysis: confirmatory factor analysis (CFA) and exploratory factor analysis (EFA). CFA tests the hypothesis that a relationship between observed variables and their underlying latent construct exists (Suhr, 2006). The researcher is able to specify the number of factors needed in the data and which measured variable is associated with which latent variable. EFA is a variable reduction technique which enables that all measured variables can be related to every latent variable, so a relationship does not perse needs to be substantiated by literature. The main difference between CFA and EFA is that for

CFA the variables are only able to load on the factor that was theoretical underpinned a priori of the analysis, while for EFA no structure is known beforehand and every variable is able to load on every factor (Mueller & Hancock, 2001).

Both factoring techniques have the goal of uncovering latent factors. The aim of a confirmatory factor analysis is to establish to what extent the model fits the data and thus can be used for instruments that have been tested before (Osborne, 2014). An exploratory factor analysis however is often used for instruments that have never been tested before (Osborne, 2014). Since mobility hubs are a new concept, and the literature used is often linked to shared mobility or MaaS, EFA is the best technique to be used.
Principal components analysis (PCA) is another reduction technique, but should not be mixed up with exploratory factor analysis. EFA is based on the common factor model whereas, PCA is not. This makes that EFA analyses the common variance, while PCA analysis the total variance (Schreiber, 2021). This can be explained by the visualization in Figure 5.

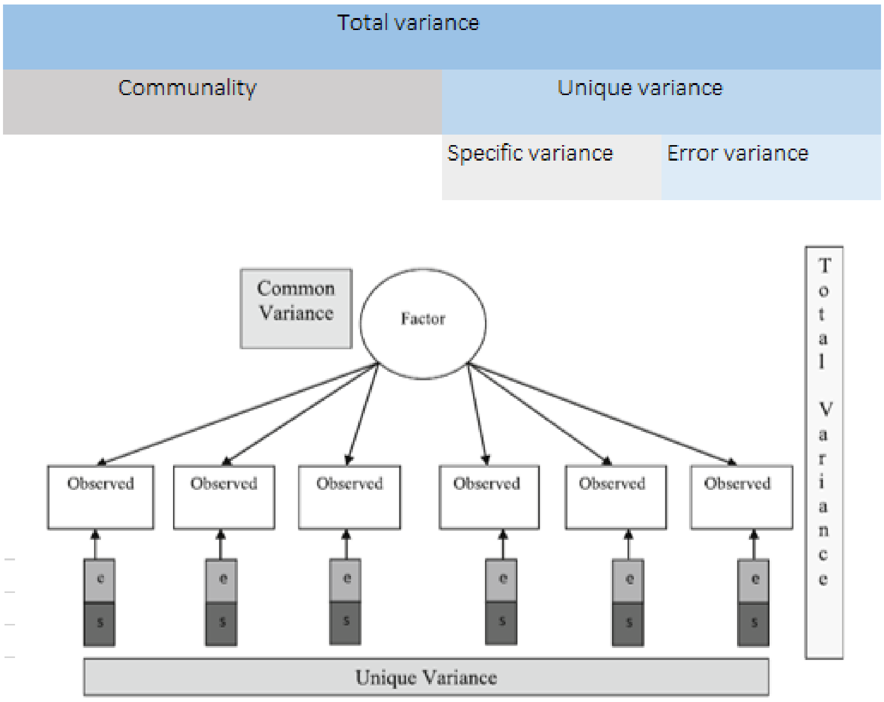


Figure 5: Factor model and its variances, retrieved from Schreiber (2021)

The total variance is made up of the common variance (variance shared with other variables; communality) and unique variance (variance for the specific variable, not shared with other variables) (Schreiber, 2021). The unique variance in turn is made up of the specific variance (variance which is attributable to the construct in some related way) and error variance (errors of measurement that are not explained by the specific or common variance) (Schreiber, 2021). Another difference between PCA and EFA is that EFA reproduces the correlation matrix (see next section) with a number of factors which all have the same importance. PCA extracts the maximum variance from the data with the first factor having the most variance. Each factor that follows, has a lower variance than its predecessor. Moreover, for EFA the shared variance is estimated by the communalities, which avoids having systematic errors when revealing the underlying factor structure. Using PCA, systematic errors will play a part, which may have a negative impact on the variance estimations (Schreiber, 2021; Van 't Veer, 2021).

The steps needed to perform an EFA is shown in Figure 6. Each step and its actions are explained below.

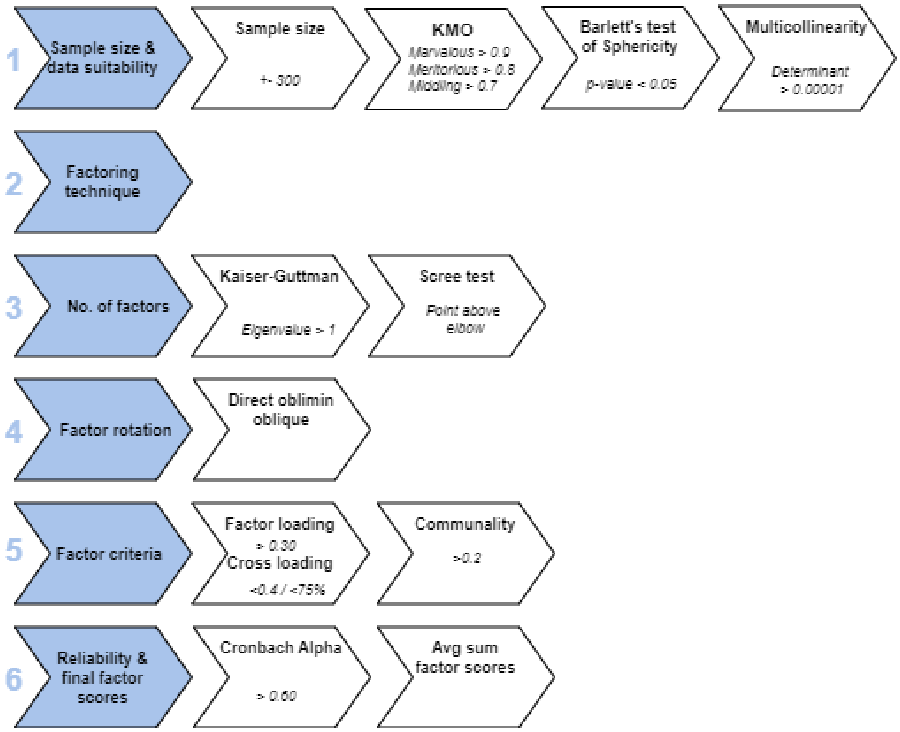


Figure 6: Steps needed to perform an Exploratory Factor Analysis

Sample size and data suitability

The first step in conducting an EFA is to check whether the sample size is large enough and if the respondents data is suitable. There is much debate on the necessary sample size needed for factor analysis. Some researchers focus on the number of variables (i.e. questions asked) to determine the sample size. According to Field (2009), the common rule is to have at least 10–15 participants per variable, while Kass and Tinsley (1979) recommend having between 5 and 10 participants per variable. Kass and Tinsley (1979) indicate that from 300 respondents on, the test parameters tend to be stable regardless of the participant to variable ratio. According to Suhr (2006), the minimal number of respondents for reliable results is more then 100 observations and 5 times the number of items. According to Schreiber (2017), the sample size is depended on communality: when communality of the variable becomes lower, the importance of sample size increases. When all communalities are above 0.6, a sample size of 100 may be enough. With communalities of about 0.5, a sample size of between 100 and 200 is recommended, communalities well below 0.5 require samples of above 500 respondents. What's clear from above research, is that a sample size of about 300 respondents will probably provide a stable factor solution. Having less respondents is possible, but requires an adequate measure of the communalities.

An additional way to determine whether your sample is adequate is by using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (Schreiber, 2021). The KMO value lies between 0 and 1, with 0 indicating a disperse correlation matrix and a KMO value near 1 indicates a dense pattern of correlations (Schreiber, 2021). According to Kootstra (2004), the sample is adequate if the KMO value is greater than 0.5. The book of Field (2009) uses the following categorization:

- Marvelous: values > 0.90
- Meritorious: values > 0.80
- Middling: values > 0.70
- Mediocre: values > 0.60
- Miserable: values > 0.50
- Unacceptable: values < 0.50

When the sample is adequate, a correlation matrix can be computed between each pair of variables. Regarding the correlation matrix, two things are important: the variables should be intercorrelated, but should not correlate too highly (Field, 2009). Firstly, the intercorrelation can be checked using Bartlett's test of spherity, which tests the null hypothesis that the population correlation matrix resembles an identity matrix (Field, 2009). This test has to be significant (p-value < 0.05), which means that the correlations between questions are significantly different from zero and the null hypothesis thus is rejected (Kootstra, 2004). This implies that there are correlations between variables (Field, 2009). Secondly, it is important to avoid high multicollinearity, which means that variables that are very highly correlated. This would give problems in identifying the unique contribution of the variables to a factor (Field, 2009). Multicollinearity can be detected via the determinant of the correlation matrix. A determinant greater than 0.00001 is desired, which indicates that there is no multicollinearity.

Factoring technique

The following step is to choose a factoring technique in order to obtain the eigenvalues. The factoring technique determines how many factors should be extracted from the data (Field, 2009). The concept of eigenvalues will be explained in the next section. Different techniques can be used for factor extraction, from which the Principal Axis Factoring (PAF), Principal Components Analysis (PCA) and Maximum-Likelihood Method are the most used ones. The different techniques will lead to slight different eigenvalues (Schreiber, 2021). Below, a description is given for the above mentioned techniques.

The Maximum-Likelihood method forms estimates of the population factor loadings which are most likely to produce the observed correlation matrix (Schreiber, 2021). An important notion here is that the sample is from a multivariate normal distribution. This results in participants being randomly selected and the used variables represent the population of variables of interest. An advantage of this method is that it is possible to generalize the sample to a larger population (Field, 2009).

When the Maximum-Likelihood method could not be run due to multivariate normality problems, Principal Axis Factoring is a good alternative (Schreiber, 2021). Principal Axis Factoring uses the original correlation matrix and consequently, the factor loadings are used to estimate new communalities and replace the old communality. This process continues until the new communalities are very small or meet a previously set criterion (Schreiber, 2021).

Principal Components Analysis is a factor extraction method which form uncorrelated linear combinations of the observed variables (Field, 2009). It focusses on maximizing the variance of the first components (Schreiber, 2021). Successive components show subsequent smaller portions of the variance and are all uncorrelated with each other (Schreiber, 2021). When more than 30 variables are included in the sample and they have a high reliability, the PCA and PAF are similar (van der Veer, Lohuis, & Couvreur, 2020). A disadvantage of both the PAF and PCA is that the sample could only be generalized to the entire population if the use of different samples yields the same factor structure (Field, 2009).

Define number of factors

The determination of the number of factors is done using three measures: the Kaiser rule, a scree plot and a minimum of 3 acceptable factor loadings per factor. First two methods are based on eigenvalues, which represent the total amount of variance in the variable that is associated with a factor (Schreiber, 2021). The first step is to follow the Kaiser rule, which is based on eigenvalues of the unreduced correlation matrix. The Kaiser rule recommends to retain only the factors which have an eigenvalue larger than 1 (Field, 2009; Kootstra, 2004). According to Schreiber (2021), the Kaiser rule has shown to be unreliable and thus needs to be checked using the scree plot. The scree plot shows a plot of eigenvalues and factor numbers. The shape of the plot is used to determine the optimum number of factors. The objective of a Scree Plot is to visually isolate an elbow, which can be defined as the point where the eigenvalues form a liner descending trend (Kootstra, 2004). The number of factors should be included in the model for which cumulative percentage of variance reaches a satisfactory level. The general recommendation is that the factors explaining 60-80% of the variance should be retained in the model (Field, 2009; Kootstra, 2004). Lastly, it is necessary to have at least 3 items per factor which all have a loading greater than 0.40 (Samuels, 2017). When this is not the case, the factor can be extracted from the model.

Factor rotation

After conducting the number of factors, it might be difficult to interpret and name the factors on basis of their factor loadings (Kootstra, 2004). Factor rotation can be a solution for this by calculating the loading of the variable on each factor (Field, 2009). Overall, most variables have high loadings on the most important factor and small loadings on the other factor (Field, 2009). There are two types of rotations, orthogonal rotations and oblique rotations. Orthogonal rotations assume that the factors are not correlated while oblique rotations assume that the factors do correlate (Field, 2009). Orthogonal rotations often use the varimax method and oblique rotation mainly uses the direct oblimin method (Kootstra, 2004). It depends on the theoretical background whether to use one of the rotational techniques (Field, 2009). If it is expected that the underlying factors are independent, one should choose the orthogonal rotation. When there might be assumptions that the factors correlate, oblique rotations should be used. According to Field (2009), the use of orthogonal rotations is nonsense for naturalistic data, especially for any data involving humans.

Factor criteria

After determining the number of factors, the next step is to determine which variables belong to which factor. This is checked using three criteria: the factor loading, the cross-loading and the communality. According to Field (2009), a factor loading of > 0.3 is acceptable. Stevens (2002) compared the factor loading with the sample size and came up with the following values:

Table 3: Factor loading compared with sample size, from Stevens (2002)

Sample size	Factor loading
50	>0.722
100	>0.512
200	>0.364
300	>0.298
600	>0.210
1000	>0.162

Furthermore, cross-loadings are important to decide upon which variables should be linked to a factor. Cross-loading are high loadings of a variable with more than one factor (Kootstra, 2004). There should be as low cross-loadings as possible. According to Taherdoost (2016) cross-loadings above 0.40 should be deleted. The article of Samuels (2017) indicates that the factor cross-loading should not be too high. As an indication, the factor cross-loading should not be higher than 75%, compared to the highest factor loading of that item.

Lastly, communality is important. As explained earlier, communality is the variance of observed variables by the overarching factor. The article of Child (2006) indicates that a variable should be deleted when the communality is less than 0.20, which shows that the common variance is only 20% and thus 80% is unique variance.

Reliability and final factor scores

When the amount of factors have been decided on, the reliability of the factors must be measured in order to check the ability of the questionnaire to measure consistently (Van 't Veer, 2021). This is done by measuring the reliability using Cronbach's Alpha. A high value of Cronbach's Alpha tells if the items of each factor are coherent within the factor. When the scores of each of the items correspond highly with each other, the construct can be said to demonstrate 'acceptable reliability' (Straub & Gefen, 2004). According to Straub and Gefen (2004), a Cronbach's Alpha higher than 0.60 is acceptable for exploratory research. This is confirmed by the study of Taber (2018), who did research into the interpretation of different alpha values.

The final step is to compute a factor score, instead of having all separate variable scores. There are multiple ways of doing this. The easiest way is to sum up the variable scores which are related to the same factor and divide it by that specific number of variables (Schreiber, 2021). There are also more complex methods, which creates factor scores from the weights (e.g. Regression, Bartlett, Anderson-Rubin) (Schreiber, 2021).

2.4 Latent Class Cluster Analysis

For sub question 3 and 4 the output of the Latent Class Cluster Analysis is needed. LCCA is a probabilistic-based clustering technique that segments population groups with similar preferences and characterizes the socioeconomic profiles of these population groups (Wang, Yan, Zhao, & Cao, 2021). Using LCCA, individuals are grouped in different classes (or clusters) according to an unobserved latent class variable that explains their responses on a set of observed indicators (Alonso-González, Hoogendoorn-Lanser, van Oort, Cats, & Hoogendoorn, 2020; Molin et al., 2016). LCCA is a useful method, since it is a model based clustering technique, which probabilistic assigns individuals to clusters (Molin et al., 2016). LCCA is different than the common clustering technique in the transport domain, which relies on ad-hoc and deterministic classification method of conventional cluster analysis to identify homogeneous clusters (Maarten Kroesen, 2021). Benefits of LCCA includes the usage of statistical criteria to find the optimal number of classes, it can deal with different scale types of variables (i.e. nominal, ordinal, continuous, count) and the significance of the model parameters can be computed (Molin et al., 2016). Moreover, the probabilistic-based clustering mechanism introduces uncertainties when assigning individuals into different segments, generating more homogeneous segments than deterministic-based clustering techniques (Molin et al., 2016; Wang et al., 2021). LCCA is executed using the software of LatentGOLD (v5.1). The outcomes of both the EFA and LCCA help to answer sub questions 3 and 4, as well as the main research question.

Below, the mathematical formulation of a Latent Class Cluster Model with covariates can be seen (Equation 1). More specifically; the probability of observing a specific sequence of responses on an indicator (i.e. the responds pattern) is formulated (Magidson & Vermunt, 2016). The equation consists of two parts: the probabilities of belonging to a particular latent class given an individual's covariate values and the probabilities of certain responses on the indicator variables given latent class membership (Magidson & Vermunt, 2016; Molin et al., 2016). A covariate is an exogenous variable (e.g. age, income) that vary between clusters and that may be used to predict class membership (Magidson & Vermunt, 2016).

$$f(y_i|z_i^{cov}) = \sum_{x=1}^{K} P(x|z_i^{cov}) \prod_{T=1}^{T} f(Y_{it}|x) \quad (1)$$

where:

x = latent variable
T = number of indicators
y_i = total set of responses of individual i
z_i^{cov} = individual i's set of covariates
Y_{it} = responds of individual i to indicator t

Using this equation, the covariates affect the latent variable (i.e. clusters), but have no direct effect on the indicators (Magidson & Vermunt, 2016). This can be seen in Figure 7, where the covariates cause the latent variable. Moreover, it is assumed that the indicators are mutually independent (r=0) given that one belongs to a certain latent class, which is called the local independence assumption (Magidson & Vermunt, 2016; Molin et al., 2016). The covariates are used to predict the degree of class membership are assumed to correlated with each other (Magidson & Vermunt, 2016). For this reason, a LCCA model consists of two parts: a measurement part where the latent classes explain the associations between the indicators and a structural part where covariates are used to predict class membership of individuals (Magidson & Vermunt, 2016; Ton et al., 2020).

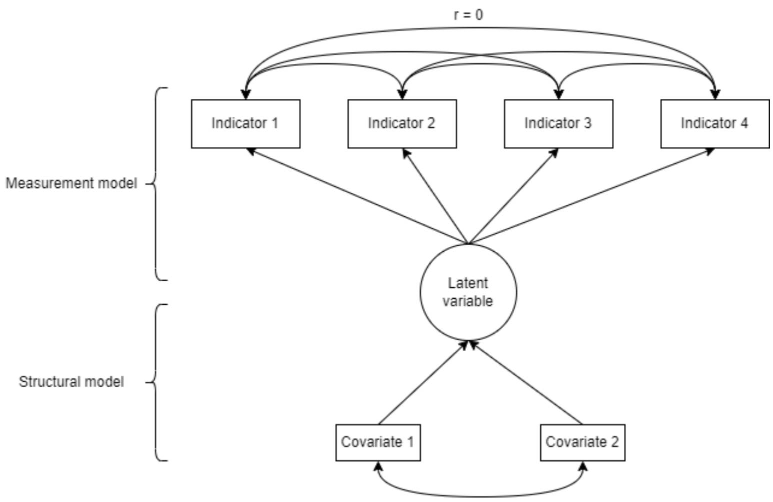


Figure 7: Latent Class Cluster Model, from Maarten Kroesen (2021)

The steps used by the study of (Van 't Veer, 2021) were used as a guideline to perform the LCCA. The steps can be seen in Figure 8 and are explained below.

Model fit

The first step is to determine the model fit. Using Latent GOLD, three different chi-squared statistics are reported, which can help by determining whether the specified model fits the data (Magidson & Vermunt, 2016):

the likelihood-ratio chi-squared statistic L^2, the Pearson chi-squared statistic X^2 and the the Cressie-Read chi-squared statistic CR^2. The most widely used approach to determine model fit uses the L^2 statistic (Magidson & Vermunt, 2004). The null hypothesis of the chi-squared test indicate that no relationship exists on the variables in the population; they are independent (Maarten Kroesen, 2021; Magidson & Vermunt, 2016). The greater the Chi-square value the greater the dependence (Maarten Kroesen, 2021), which indicates that a lower L^2 value is recommended for a better model fit (Magidson & Vermunt, 2004). A model fits the data well if the p-value of L^2 is > 0.05 (Maarten Kroesen, 2021; Magidson & Vermunt, 2004). The chi-squared distribution should not be used to compute the p-value in situations involving sparse data, since the approximation of L^2 is poor (Magidson & Vermunt, 2004). When having sparse data, the bootstrap approach is a good alternative to estimate the p-value (Langeheine, Pannekoek, & Van de Pol, 1996). An important notion regarding the model fit is when having indicators with a continuous scale, LatentGOLD is not able to determine the chi square value (Magidson & Vermunt, 2016).

Number of classes

To determine the appropriate number of classes, first the measurement part of the model is estimated, including only the indicators (Ton et al., 2020). The covariates are thus not yet used for determining class membership. The overall goal here is to find the most parsimonious model, so the model with the smallest number of latent classes, which can sufficiently describe the associations between the indicators (Molin et al., 2016). The number of clusters has to be determined based on the fit of the measurement model. Various statistical tests are available to determine the optimal number of classes with the highest model fit: Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC) and Bivariate Residuals (BVR). For both BIC and AIC the guideline is to choose the number of clusters with the lowest value (Magidson & Vermunt, 2016). When it happens that the values remain being smaller each increase in clusters, percentual change in the BIC-value compared to the previous cluster model can be used in order to determine the optimal number of classes (Alonso-González et al., 2020; Van 't Veer, 2021). When the percentual change in the BIC-value shows only a small improvement in model fit, the optimal number of clusters is reached. Besides BIC and AIC, the Bivariate Residuals (BVRs) is a useful measure that provides information about the local model fit (Maarten Kroesen, 2021). The Bivariate Residuals are estimates in order to improve the model fit, when including direct effects between indicators moreover ensuring that that the local independence assumption is violated (Molin et al., 2016). The BVR is calculated using the Pearson Chi-squared (L^2) divided by the degrees of freedom, suggesting that for 1 degrees of freedom (1 df) a BVR greater than 3.84 is statistically significant at a 5% level (Schreiber, 2017). In other words, a Bivariate Residual value greater than 3.84 shows that a significant degree of covariation exists between two indicators (Molin et al., 2016). When keeping in mind the local independence assumption this is undesirable, which means that a BVR value smaller than 3.84 is preferred.

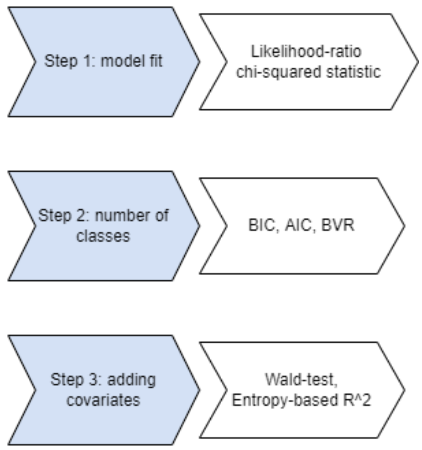


Figure 8: Steps needed to perform LCCA

Adding covariates

The next step is to combine the measurement model and the structural model, so that the effects of the covariates on latent class membership can be explored (Alonso-González et al., 2020). When including the covariates, this leads to changes in clusters but on the other side helps to differentiate individuals in the different clusters further (Alonso-González et al., 2020). In the end, this will provide better insights per cluster. The covariates are added to the model, and based on the Wald statistics it is decided whether to keep the covariate in the model (Magidson & Vermunt, 2016). The Wald test is a chi-squared test, with the number of degrees of freedom equal to the number of constraints (Magidson & Vermunt, 2016). Covariates are added to the model when they are significant (Wald > 3.84 and $p < 0.05$), meaning that the covariate likely has an effect on class membership in the population (Maarten Kroesen, 2021). Subsequently, insignificant covariates (Wald < 3.84 or $p > 0.05$) are removed and added as inactive covariates. The procedure is as follows: first, all covariates are added to the model. By means of backwards elimination insignificant parameters will removed (and added as inactive covariates) (de Viet, 2019; Van 't Veer, 2021), starting with the most insignificant covariate. In the end, the significant covariates remain and are labeled as active covariates. It is possible that covariates are significant at first, but become insignificant when another covariate is added. The insignificant covariate will then still be removed from the model (Maarten Kroesen, 2021). The combination of the active covariates, together with the indicators, result in the final model (Ton et al., 2020). The final step is to check how accurately the model defines the classes, based on the observed variables (Magidson & Vermunt, 2016). In other words, an estimate of the probability is given that each of the individuals is present in the different clusters. This data can be summarized into a single number, called the entropy R-squared (Magidson & Vermunt, 2002). The entropy R^2 has a value between 0 and 1, where values closer to 1 illustrate perfect prediction (DiStefano & Kamphaus, 2006). Values above 0.80 indicate good classification of the individual cases into classes (Clark & Muthén, 2009), whereas a value below 0.60 is discouraged (Weller, Bowen, & Faubert, 2020).

3 Literature study

3.1 State-of-the-art mobility hubs

In this section, the concept of a neighborhood mobility hub will be thoroughly explained. This begins with defining mobility hubs and its functionalities. Subsequently, a definition of a neighborhood mobility hub will be formed. Furthermore the type of mobility offered at a neighborhood hub will be discussed as well as the previous research into neighborhood mobility hubs. The section ends with a literature review on the potential hub users and its most common characteristics.

3.1.1 Defining mobility hubs

The concept of a mobility hub has increasingly been receiving attention in literature. Besides scientific literature, more and more grey literature is emerging on mobility hubs. What is noticeable is that almost every study has its own definition of a mobility hub. This is because each study defines mobility hubs taking into account their own specific case, and it is still an emerging concept. Table 4 lists a number of definitions of academic as well as gray literature.

Table 4: Definitions mobility hubs

Author(s)	Definitions of mobility hub
Anderson, Blanchard, Cheah, and Levitt (2017)	Mobility hubs are agglomerations of transportation modes that concentrate emerging share mobility services in well-defined locations, delivering several benefits to users.
Aono (2019)	Mobility hubs are defined as a place where different sustainable transportation modes are integrated seamlessly to help promote connectivity, and are usually located in centralized areas
Coenegrachts, Beckers, Vanelslander, and Verhetsel (2021)	A location where shared mobility is concentrated. The shared mobility hub clusters different new and conventional mobility services at a physical location. Its functions, services, facilities, and infrastructure requirements depend on the local urban context, including the policy goals of the different stakeholders.
Geurs and Münzel (2022)	A mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations and public or collective transport is available at walking distance.
KiM (2021c)	In their most basic form, mobility hubs are physical places where a user can transfer from one mode to another.
Kreemers, Tamis, Van Brecht, and Van Gent (2021)	eHUBs are physical places, in neighbourhoods on the street, in (municipal) car parks, and in office car parks, where shared e-bikes, shared e-cargo bikes, shared e-scooters, and shared e-cars are offered. These e-modalities can be accessed via a smartphone.
Snel (2020)	A concentrated place with public transport and shared electric mobility, max. 300 metres walking distance from your home. Shared mobility uses less parking and infrastructure, creating space for landscaping, playgrounds, stormwater storage and heat-stress reduction.
ARUB (2020)	In the current transport system, mobility hubs are commonly seen as physical places that connect a variety of transport modes. A mobility hub can be anything from a bus stop and a bike sharing station to an inner-city main train station.
CoMoUK (2019)	A mobility hub is a recognisable place with an offer of different and connected transport modes supplemented with enhanced facilities and information features to both attract and benefit the traveler.
Mobiliteitsalliantie (2019)	A physical location that enables the transfer to the most optimal modality for the onward journey
Natuur en Milieu (2020)	A mobility hub is a high-quality physical location that combines a varied range of sustainable and active means of transport with pleasant accommodation options.

These definitions have in common their physical location at which various services may be offered, often in combination with shared mobility (Anderson et al., 2017; Coenegrachts et al., 2021; Geurs & Münzel, 2022; Kreemers et al., 2021; Snel, 2020) or sustainable mobility (Aono, 2019; Natuur en Milieu, 2020). But besides these aspects, the hub definitions differ among each other in terms of size, types of mobility and services. In order to define a proper definition of hubs for this study, a closer view needs to be taken on their functions and typologies.

Functions of mobility hubs

As stated above, a mobility hub differs in size, layout and services. The services that a hub may provide can be converted into functions. The study of Geurs and Münzel (2022) made an overview of all different functions the hub might have which could be found in literature. These functions can be found in Table 5.

As can be seen in Table 5, a hub mostly consists of multiple modes, which often includes shared mobility and where a transfer between modes is possible. This corresponds to the definitions of hubs discussed in section 3.1.1. Because the concept of a mobility hub is very broad, multiple modes are more frequently present than shared mobility. In their most basic form, a mobility hubs are physical places where a user can transfer from one mode to another (KiM, 2021c). This ensures that a Park and Ride or a train station can also be depicted as an hub in its broadest definition.

Table 5: Possible functions of a mobility hub, from Geurs and Münzel (2022)

	PT	Shared Mobility included	Multiple modes	Transfer between modes	Non-mobility related facilities	Digital integration	Physical/ visual integration	Democratic integration
Advier (2021)	(x)	x	x	x	(x)	(x)	x	-
Amoroso et al. (2012)	-	-	x	x	-	-	-	-
Anderson et al. (2017)	x	x	x	x	-	-	-	-
Coenegrachts et al. (2021)	-	x	x		-	-	-	-
CoMoUK (2019)	(x)	x	x	x	x	x	x	-
Crow (2021)	-	-	x	x	x	-	-	-
DELVA et al. (2019)	-	-	x		(x)	-	-	-
Department of City Planning Los Angeles (2017)	x	-	x	x	-	-	-	-
eHUBS (2021a)	-	x	x	-	x	-	-	(x)
Garde et al. (2014)	x	-	x	x	-	-	x	-
Gemeente Utrecht (2021)	-	x	x		-	-	-	-
Gemeente Utrecht et al. (2021)	-	x	x	x	x	-	-	-
Goudappel et al. (2021)	-		x	x	(x)	-	-	-
Fallast & Huber, 2015	-	-	x	x	-	-	-	-
IGES Institut (2021)	x	x	x		-	-	x	-
Jansen et al. (2015)	x	-	x	x	-	x	-	-
KiM (Witte et al., 2021)	-	-	x	x	x	-	-	-
Metrolinx (2011)	x		-	x	-	-	x	-
Miramontes et al. (2018)	x	x	x	x	-	x	-	-
Mobiliteitsalliantie (2020)	-	-	-	x	-	-	x	-
Natuur & Milieu (2020)	(x)		x	x	x	-	x	-
Navrátilová et al. (2021)	x	(x)	x	x	-	-	x	-
Rehme et al. (2018)	-	-	x	x	-	-	-	-
Reisviahub.nl (2021)	(x)	(x)	x	x	x	-	-	x
Rube et al. (2020)	-/x	x	x	x	-	-	x	-
Schemel et al. (2020)	-	-	x	x	-	-	-	-
van Gils (2019) (eHUBs)	(x)	x	x	x	-	-	-	-
Zientek et al., 2018	-	-	x	x	-	-	-	-
Zukunftsnetz Mobilität NRW(2017)	-	-	x	x	-	-	x	-

x= explicitly mentioned in the definition/essential elements; (x)PT: walking distance to PT; other characteristics: optional element; (-/x) score depends on the type of hub

According to the literature reviewed in Table 5, often there is a connection to PT. This may be at walking distance from the hub, or fully integrated into the hub which ensures a bundling of transport flows between, for example the bus and shared mobility. This could result in opportunities for lower density areas. If for example the occupation on individual bus lines becomes too low to be financially sustainable in a rural area, the cost-effectiveness and accessibility of the system can increase by combining individual bus lines via hubs into thicker transport flows that do have sufficient occupancy.

Besides mobility, there are more functions a hub can contain. Some of the hubs reviewed have non-mobility related facilities, such as a water fountain, a point to charge a phone or parcel lockers. Aspects of visibility in public space are also considered as an important function by multiple studies. As an example, one should think of a recognizable place with signage and branding and integration in the urban environment. Digital integration (e.g. transport information, ticketing and local services) and democratic integration receive less attention in literature. For democratic integration the involvement of users is asked in order to improve the services offered. This is relative new function, applied by the municipality of Amsterdam. Users are invited to join in a participatory planning process to determine together with the municipality what the hub will look like and what the mobility will be offered (Geurs & Münzel, 2022).

Types of mobility hubs

After studying the definition and functionalities of a mobility hub (both in section 3.1.1), it becomes clear that there is no such thing as a standard mobility hub. APPM and Goudappel (2020) made an approach to categorise mobility hubs, based on two steps: the geographical location of a hub and the scale level at which the hub functions. First of all, a distinction is made based on the geographical area, which results in four zones: inner city, urban residential area, city periphery and rural zone (Figure 9).

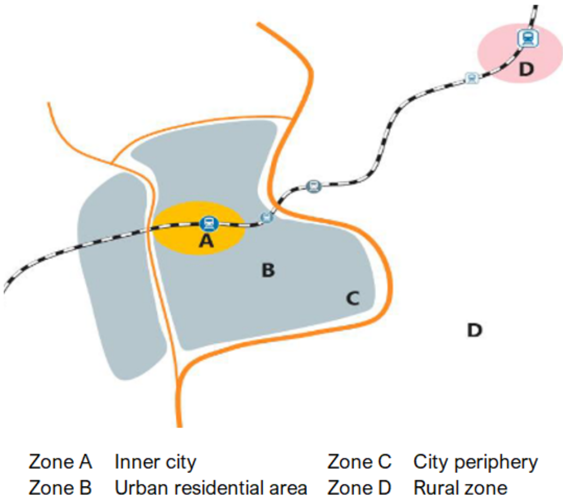


Figure 9: Geographical areas hub, retrieved from APPM and Goudappel (2020)

In the second step, the size of the catchment area is examined. A distinction is made between four levels: neighborhood or village, city, (inter)regional and (inter)national. Based on these two steps, different hub types can be distinguished:

1. City hub: large-scale hub in city center, possibly connected with regional PT network. Exposed to high volumes of passengers (APPM & Goudappel, 2020).
2. City edge hub: hub situated at the periphery (near ring road), such as carpool places with handy facilities where people transfer from car to active or collective HOV transport (APPM & Goudappel, 2020; KiM, 2021c).
3. Regional hub: transfer point from car or bicycle to PT. Combination with demand-driven flexible transport possible (APPM & Goudappel, 2020).
4. Rural hub: small-scale transfer locations in rural areas. Transfer from car or bicycle to bus or shared mobility (APPM & Goudappel, 2020).
5. Neighborhood hub: Small-scale hub, often situated in in residential area or rural area, at walking distance from home. Shared mobility is available and mostly used for first- and last-mile trips. Often connected to PT network (KiM, 2021c; Snel, 2020).
6. Logistics hub: a cargo hub at the edge of the city to establish emission-free last-mile transport, e.g. a distribution centre from where the city is supplied (Van Rooij, 2020).

In figure Figure 10, these different types of mobility hubs are visualised according to their geographical area and the size of the catchment area.

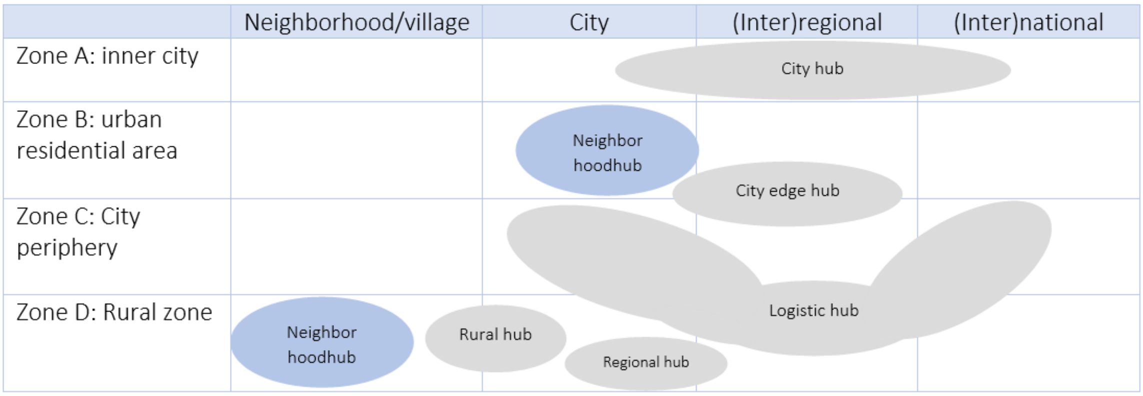


Figure 10: Distinction based on hub scale retrieved from APPM and Goudappel (2020)

Neighborhood mobility hubs

This thesis will focus on neighborhood mobility hubs. Since neighborhood mobility hubs are relatively new type of hubs, no clear definition can be found in scientific literature. In Table 6, an overview is made from the functionalities of neighborhood hubs, found in the reports of APPM and Goudappel (2020); LA Department of City Planning (2016); Mobipunt (n.d.-b). For every type of functionality it is indicated whether it is vital, recommended or optional. Just as with the functionalities of the broad concept of mobility hubs, which has been discussed in section 3.1.1, there is a lot of difference in functionalities between the papers.

Table 6: Functionalities neighborhood mobility hubs
V = Vital, R = Recommended, O = Optional

	Mobility			Mobility services							Location						Extra services			Digital	
	Bike share	Car share	Bus connection	Bike parking	Bike facilities	Kiss + Ride	Parking spaces	EV charging	Bus layover zone	Sustainable approach	Wayfinding	Cycling routes connected	Safety and security	Waiting area	Public space	Proximity living / working	Retail	Parcel lockers	Ambassadors	Real time information	Smartphone charging
(LA Department of City Planning, 2016)	**V**	O	R	**V**	O	R	-	R	O	R	**V**	R	R	R	O	-	O	-	O	R	R
(APPM & Goudappel, 2020)	**V**	**V**	O	**V**	O	-	O	**V**	-	**V**	**V**	O	**V**	O	**V**	**V**	R	O	-	**V**	-
(Mobipunt, n.d.-b)	**V**	**V**	**V**	**V**	R	R	-	-	-	**V**	R	R	-	O	R	**V**	-	O	-	O	O

From the information in Table 6, three different themes can be distinguished regarding neighborhood hubs: mobility, location and optional services.

As the scientific as well as grey literature from Table 4 and Table 6 indicated, **mobility** is the core essence of mobility hubs. In the literature discussed in Table 4, shared mobility is limited to shared (e-)bikes and shared electric cars. Dependent on the area the neighborhood hub is located in, other types of shared mobility may be interesting, such as shared cargo bikes, e-scooters (in Dutch: e-steps), or e-mopeds (Franken, 2021). Moreover, a bus connection may be a possibility. This can either be a direct connection to the hub, or within walking distance from the hub.

The second theme regarding neighborhood mobility hubs is related to the **location and visibility** of the hub. A hub must be well integrated into its environment, accessibility, road safety and social safety play a role in this. In addition, a hub must be visible and must be a landmark from which the user must be able to orientate itself easily. The neighborhood hubs are typically situated in urban residential areas and rural zones (Figure 10). Moreover, the distances to the hub should be doable and within walking distance from home. The recommended acceptable distance in the literature is generally between 300 and 500 meters, while the travel time is about 5 minutes (Geurs & Münzel, 2022).

Lastly, **optional services** may be mobility related or non-mobility related. Mobility related optional services are regarding bike parking, kiss and ride or EV-charging stations. Various non mobility related services can be offered at a neighborhood hub. Consider a charging station for a smartphone or a locker where packages can be delivered.

Using input from the definitions of hubs and their functions, a definition can be formed. Since the definition Geurs and Münzel (2022) mentioned in their article is very comprehensive, it will be changed slightly for the case of neighborhood hubs. The following definition of neighborhood hubs will be used in this thesis: *A neighborhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations which are within walking distance of home. A connection with PT as well as other types of services (mobility and non-mobility related) is possible but not required.* In Table 21, a visualisation of a neighborhood hub can be seen.

It is important to emphasize that this study mainly concerns the mobility offered by a hub. What distinguishes a neighborhood hub from, for example, Mobility-as-a-Service or separate forms of shared transport, is mainly the physical location where several types of shared mobility is offered. However, the extra functions of a neighborhood mobility hub may contribute to the adoption of the technology and are therefor not totally forgotten in this research.

Figure 11: Neighborhood mobility hub, retrieved from CoMoUK (2019)

Sub-question 1: What is a neighborhood mobility hub and what functionalities does it have?

Considering that mobility hubs are a relatively new concept, no general definition was formed yet in existing literature. Using the input from the different hub definitions and corresponding functionalities described in the section above, the following definition could be formed:

A neighborhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations within walking distance of home. A connection with PT as well as other types of services (mobility and non-mobility related) is possible but not required.

3.1.2 MaaS and mobility hubs

As discussed in the previous section, different types of shared mobility are provided on the platform of a mobility hub. These types of shared mobility are often offered by one single mobility service: Mobility as a Service (MaaS). According to Mobiliteitsalliantie (2019) it is essential that all the modes used in a mobility hub are integrated using a MaaS platform. Often, a comparison is made between MaaS and mobility hubs. According to KiM (2021c), mobility hubs are often seen as the physical component of MaaS. Mobility as a Service is not part of this research, however a description of the concept is inevitable when talking about mobility hubs. MaaS is a mobility concept which provides a single digital platform that integrates existing and new mobility services and leads to the possibility of planning and purchasing a complete door-to-door journey (Durand, Harms, Hoogendoorn-Lanser, & Zijlstra, 2018; Jittrapirom et al., 2017). MaaS assumes that users have access to different means of transport and, in the case of multimodal journeys, that a transfer is easy to make both digitally and physically (KiM, 2021c). It enables that the searching, booking and paying for the use of shared mobility and public transport is as simple as possible. This encourages travelers to choose the most suitable means of transport for each journey, instead of making a sub-optimal choice on habitual behaviour (KiM, 2021c). MaaS is relevant for mobility hubs since the services may complement each other: it makes the use of different transport modes easier and a hub improves access to the services of different providers offered at the hub (Geurs & Münzel, 2022). In addition, there is room for many mobility options, which can operate in a complementary way rather than as competitors, improving the supply of transportation options and increasing the freedom of choice for users (Machado, Hue, Berssaneti, & Quintanilha, 2018). Moreover, both services contribute to a change of travel patterns among travelers and a potential decrease of private car usage (de Viet, 2019). To conclude, MaaS users are often young, higher educated and frequent PT users (Zijlstra, Durand, Hoogendoorn-Lanser, & Harms, 2019). Since mobility hubs are closely related with MaaS it is expected that hub users share part of these characteristics with the expected MaaS users (Van Rooij, 2020).

3.1.3 Type of mobility offered at a hub

The offering of shared mobility is a core aspect of neighborhood mobility hubs. Shared mobility is the shared use of a vehicle (such as a car, bicycle, scooter, or moped) that allows a traveler to have on-demand access to transportation modes (Machado et al., 2018; Shaheen, Cohen, Chan, & Bansal, 2019). In Appendix B, an overview is given of existing neighborhood mobility hubs in the Netherlands. Hely is the biggest supplier of neighborhood hubs, having more than 80 hubs in the Netherlands. In this it is apparent that (nearly) every hub has its own mix of (shared) transport. However, the presence of shared mobility at a mobility hub is not essential for every operator.The hubs of 'Reis via hub' in total have 55 hubs, of which only one hub offers the sharing of bicycles. Neighborhood hubs of Hely and eHubs on the other hand offer a various mix of shared cars and (e-)bikes sometimes complemented with mopeds, cargo bikes or bíro's. An overview of the different hub suppliers, its hub locations and the mobility offered can be seen in Table 7. In Appendix B a more detailed explanation is given of the neighborhood mobility hubs in the Netherlands.

Table 7: Existing neighborhood mobility hubs in the Netherlands

Company	Cities	Type of passenger mobility offered
Hely	Amsterdam, Breda, Capelle ad IJssel, Delft, Rotterdam, Utrecht, the Hague, Ede, Eindhoven, Haarlem, Helmond, Leiden, Rijswijk	e-cars, (e-)bikes, cargo bikes and e-scooter
eHubs	Amsterdam, Arnhem, Nijmegen	e-cars, biro's, (e-)bikes, cargo bikes and e-scooter
Mobipunt	Nieuw-Vennep, Hillegom, Hoofddorp, Zandvoort, Haarlem, IJmuiden, Beverwijk, Alkmaar, Schagen, Middenmeer, Wieringerwerf, Anna Paulowna, Den Oever, Den Helder, 't Veld,	e-cars, bikes
MobiHUB	Amsterdam, Rotterdam, Amstelveen	(e-)bikes, cargo bikes
Reis via hub	Multiple locations in Drenthe and Groningen	bicycles

When investigating literature, many studies have documented the modalities and types of sharing regarding shared mobility. This study will use a scheme from van Gerrevink (2021), which is based on Machado et al. (2018); Münzel, Boon, Frenken, Blomme, and van der Linden (2019); Roukouni and Correia (2020); Shaheen et al. (2019). The scheme is used because of its relevance to neighborhood mobility hubs and is visualised in Figure 12. The scheme is adjusted slightly, so that (e-)moped and (e-)scooter sharing also has the option to be station based. This ensures that it fits better within the concept of a mobility hub. There are three types of shared mobility: 1) car sharing, 2) (e-)mopeds e-scooters sharing and 3) (e-)bike sharing which are all explained below.

Car sharing

There are multiple carsharing models, which can be distinguished into station based, free-floating and personal vehicle sharing. Station based car sharing operate from fixed stations or hubs, from where a trip starts (Shaheen et al., 2019). For roundtrip carsharing, users must return the shared vehicle to the same location from where it was accessed. For the one-way service, the start and end of a trip is at different stations, so that a network is build of different locations (Ferrero, Perboli, Vesco, Caiati, & Gobbato, 2015). In case of electric car sharing, mostly a station based service is used because of the need for charging stations (Ferrero, Perboli, Vesco, Musso, & Pacifici, 2015).

Using a free-floating service, vehicles can be freely parked in a certain operational area and trips can start and finish in any point in this area (Ferrero, Perboli, Vesco, Caiati, & Gobbato, 2015; Shaheen et al., 2019). Using a free-floating service, often a one-way trip is made (Shaheen et al., 2019). An advantage of one-way trips over roundtrips is the increased flexibility and the potential to further enhance first- and last-mile connectivity (Shaheen et al., 2019). However, using a free-floating service, vehicles may need to be redistributed over the network (Ferrero, Perboli, Vesco, Musso, & Pacifici, 2015).

Moreover, there is a personal vehicle sharing system, where the vehicle is owned by individuals. With peer-to-peer (P2P) carsharing, cars owned by individuals are made temporarily available for shared use (Shaheen, Bansal, & Chan, 2015). The service is often facilitated through a third-party operator and mainly functions like the station based system (Nijland & van Meerkerk, 2017; Shaheen et al., 2019). P2P is rather well represented in the Netherlands. In 2020, 83% of the total shared vehicles was based on P2P sharing (KiM, 2021b). However, despite the large share of P2P vehicles, their use is lower than that of business-to-consumer (B2C) shared cars. A special form of personal vehicle sharing is fractional ownership where a vehicle can be subleased to multiple individuals (Shaheen et al., 2015). These individuals pay a portion of the monthly and maintenance expenditures in exchange for the usage of the car.

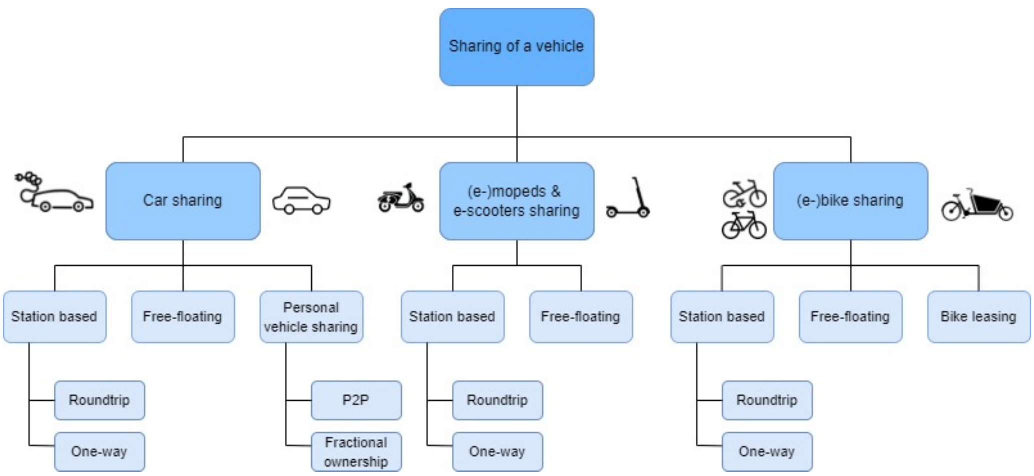


Figure 12: Shared mobility and its modalities, modified from van Gerrevink (2021)

(e-)mopeds and e-scooters
Another type of shared mobility are the (e-)mopeds and e-scooters. The term e-scooters refers to standing e-scooters (in Dutch: e-steps), whereas other e-scooters are referred to as e-mopeds (Roukouni & Correia, 2020). At the moment of writing, e-scooters are not yet legally allowed in the Netherlands (Rijksoverheid, n.d.). The Ministry of Infrastructure and Water Management are currently considering to allow e-scooters on the public roads. The scooters and mopeds focuses on short term use, because of the limited range and speed (Shaheen et al., 2019). According to Howe (2018), the shared moped is mainly used for commuting or leisure time activities. Most of the services are available using free-floating, which account for 99% of the supply. However, this does have drawbacks: the shared e-scooters and (e-)mopeds cause a lot of parking nuisance on the street and sidewalks (Lelieveld, 2022). Moreover, the e-scooter has negative impacts regarding an increase in injuries among e-scooter drivers (Mayhew & Bergin, 2019). With the emerging of mobility hubs, it is expected that more scooters and e-mopeds will be station based.

(e-)bike sharing
In recent decennia, the bicycle sharing market emerged a lot: in 2005 17 public bicycle sharing systems existed all over the world, compared to 1600 in 2018, accounting for more than 18 million bicycles (Roukouni & Correia, 2020). There are multiple sharing systems suitable for bicycles, from a station-based round-trip access (bicycles must be returned to same station where they were picked-up) to a station-based one-way access (bicycles can be returned to any station) (Machado et al., 2018). In the Netherlands, the OV-fiets is a typical example of a round trip station based sharing system, good for about 5.2 million trips in 2019 (KiM, 2021b). It is estimated that 80% of all shared bicycles in the Netherlands are related to the OV-fiets (KiM, 2021b). OV-fiets is owned by the Dutch Railways and the bicycles can be picked up (and returned) at train stations. Another sharing system is the free floating bicycle sharing system which allows the user to take, or hand in, a bicycle at any location within a predefined operational area (Machado et al., 2018). A new form of sharing system is the bicycle leasing where users can rent bicycles for a subscription fee per month. Swapfiets is a company is the Netherlands

offering this service in combination with repairing the bicycles without extra costs (Swapfiets, n.d.). Bicycle sharing programs provide numerous advantages, including improved PT connectivity, reduced travel time and expenses in city centers and improved physical health (Machado et al., 2018).

E-bikes and electric cargo bikes are relative new entries on the bicycle sharing market (Roukouni & Correia, 2020). The e-bike is gaining popularity because of its higher speed compared to the normal bicycle, still providing an adequate level of physical activity (McQueen, MacArthur, & Cherry, 2020). Because of the speed, it is expected that the shared e-bike is often used for longer journeys, making it more competitive with public transport and car trips (KiM, 2021b; McQueen et al., 2020). The studies of Guidon, Becker, Dediu, and Axhausen (2019) and Romanillos, Moya-Gómez, Zaltz-Austwick, and Lamíquiz-Daudén (2018) both indicate that a large proportion of shared (e-)bike trips are being used for commuting. KiM (2021b) does indicate that the electric shared bicycle is a relatively expensive product for providers. In the case of the Netherlands, most bicycles (OV-fiets) are offered at stations and, given the possible degree of competition with PT, the electric shared bicycle may be less encouraged by providers KiM (2021b). A shared electric cargo bike can be used to transport goods and/or children, which makes it a possible substitution of private car trips (Becker & Rudolf, 2018). Moreover, according to Becker and Rudolf (2018), the availability of shared electric cargo bicycles may lead to a reduction of car ownership, especially in dense cities.

Usage per mode

The usage of shared modes of transport will be different per density area, city and even differs per country. In a sense, literature can give an indication of how travelers make use of shared mobility. Table 8 shows the typical length range and peak hour of shared mobility trips found by Liao and Correia (2019). For an electric shared car, an average trip length of 28 kilometers is found (Kramer, Hoffmann, Kuttler, & Hendzlik, 2014). A study by KiM (2021b) found that that the shared car is mainly used for relatively long distances, whereby half of the private trips are longer than 30 kilometers, and for business use longer than 43 kilometers. It's important to say that these numbers are related to station-based car sharing. According to Liao and Correia (2019), electric cars are the most commonly chosen mode within shared e-mobility. The electric car is mainly used for visiting friends and family, followed by shopping, day trips and business trips (KiM, 2021b). Next to the the cargo bike, the two-wheelers have a typical trip length which is quite similar: below 5 kilometers and mostly around 2 kilometers (Guidon et al., 2019; Howe, 2018; KiM, 2021b; Romanillos et al., 2018). This range is slightly higher than than the trip length of shared bicycles in the Netherlands (KiM, 2021b). For journeys within 5 kilometers, e-bikes, bicycle and scooters can be a good alternative to private cars as they have economic advantages (Smith & Schwieterman, 2018). For longer trips they tend to be more expensive and require more physical effort (Liao & Correia, 2019). The study of Becker and Rudolf (2018) found that the average trip length for shared e-cargo bike is somewhat higher: 15.48 kilometers.

With regard to peak hours, Table 8 shows that e-bikes roughly correspond to be used in commuting peak hours, which can be explained by the fact that e-bikes are often used for traveling between home and work (Liao & Correia, 2019). It is interesting to mention that the morning peak usage cannot be seen in case of bicycle sharing (KiM, 2021b). This can be explained by the fact that normal bicycles are often used for social-recreational purposes (KiM, 2021b; van Waes, Farla, Frenken, de Jong, & Raven, 2018). The peak usage of the electric vehicles and e-mopeds are comparable. The rides are more spread out over the day compared to e-bikes and usage is at a continuously high level from early afternoon to evening (Liao & Correia, 2019).

Table 8: Length and temporal distribution of shared mobility trips, retrieved from Liao and Correia (2019)

Mode	Trip length	Peak usage
E-car	Mean length 28 km (Kramer et al., 2014) tour: 50% longer than 30 km (KiM, 2021b)	Weekday 3-8 PM Weekend 2-8 PM Weekend higher than weekday (Hu, Chen, Lin, Xie, & Chen, 2018)
Bicycle	Avg: 2.1 km, 50% of trips below 1.6 km (KiM, 2021b)	Afternoon and evening (KiM, 2021b)
E-bike	Most frequent trip: 2 km (Romanillos et al., 2018) 1-3.5 km (Guidon et al., 2019)	Weekday: morning commute, afternoon and evening (Romanillos et al., 2018)
E-moped	4-5 km 15-20 min (Howe, 2018)	Weekday: early evening Weekend: continuous increase in afternoon and evening
E-cargo bike	15.48 km (Becker & Rudolf, 2018)	

3.1.4 Previous research into neighborhood mobility hubs

Now that the concept of a neighborhood mobility hub is defined together with the types of mobility that is offered at a hub, an overview is given of previous research on neighborhood mobility hubs. More specifically, research about the usage or intention to use a neighborhood mobility hub and the impact a neighborhood hub has on car ownership. It needs to be noticed that current research available is mostly limited to theses.

Intention to use neighborhood mobility hubs

Multiple studies investigated the current usage of neighborhood mobility hubs or the intention to use hubs in the future. The thesis of Van Rooij (2020) distributed a survey (N=44) among residents of different cities in Noord-Holland and Zuid-Holland with a neighborhood mobility hub within 400 metres. 20% of the respondents actually used the hub. 63% of the neighborhood knew about the hubs existence, with large differences between neighbourhoods. One of the findings of Claasen (2020) (N=1174) is that the willingness to use a hub is low and travelers prefer to use their private car instead of shared mobility. When they make use of shared mobility, the car is the most preferred mode of transport. Walking time towards a hub and increased perceived travel costs are determinants that cause a traveller not to use the hub. People having a positive attitude towards shared mobility are more willing to use a hub. An interesting finding of Claasen (2020) is that the likelihood of using a more sustainable mode of transport increases if other people would use it as well.

An EU funded project by Kreemers et al. (2021) did research into car owners' motives for the possibility of trying out shared electric modalities offered at a e-HUB in Amsterdam (N=564) and Leuven (N=257). The majority of respondents in both cities (Amsterdam 70%, Leuven 65%) indicated that they see mobility hubs as a valuable addition to their city. However, when they should use it themselves, only one fifth of the respondents (Amsterdam 23%, Leuven 22%) are likely to try out a vehicle from the eHUB in the coming month. The article mentioned a number of motivations. The main reason for not using hubs is that there is no need for the respondents (44% in Amsterdam, 27% in Leuven), the mobility need is already met with the vehicles that the respondents own. In addition, trying out eHUBs entails additional costs on top of the costs for private car ownership (Amsterdam 29%, Leuven 26%). Planning is also an important reason for not to use a hub (Amsterdam 13%, Leuven 18%). Using shared mobility services from an eHUB requires planning and reservation while having a car gives car owners the opportunity to leave spontaneously whenever they want (Kreemers et al., 2021) . There are also a number of reasons why people do want to use a hub. Curiosity is the main reason according to the respondents (Amsterdam 35%, Leuven 20%): Several participants were unfamiliar with the concept of a hub and interested in how it works. Strangely enough, the attractive pricing (Amsterdam 23%, Leuven 28%) is also mentioned: 'If shared transport is cheaper than my own car, I would try it'.

A stated choice experiment (N=574) of Franken (2021), conducted in the Randstad, show that there is a willingness to use shared mobility services from a mobility hub. In the short term, for work related trips the shared e-car has the preference over the private car. Residents of city centres have more preference of using shared mobility than residents of suburban and rural areas for commuting trips of 7.5 kilometres. For the long term effect, there seems to be an even higher preference for mobility hubs over private cars. The study indicated that the willingness to use hubs is higher in city centres than in suburban and more rural areas. The latter is consistent with a pilot study (N=195) in Gothenburg, where the adoption rate for the use of shared mobility services of respondents living in city centres is higher than respondents living in suburban areas (Strömberg, Karlsson, & Sochor, 2018).

Fioreze, de Gruijter, and Geurs (2019) did ex ante research on shared mobility in a neighborhood in Den Bosch. The results indicated that there was a low interest (20%) in using shared mobility on the long term. However, 46% of the residents are curious about the concept of shared mobility and might experiment with it in the future. The author indicated that residents who are satisfied with their existing transport possibilities were not yet convinced that MaaS or shared mobility would offer value added for them and enrich their satisfaction with travel. A study (N=203) conducted by de Viet (2019) shows that shared mobility has the potential to change peoples travel behavior, despite the current low adoption rate. The willingness to use shared mobility would be higher among household having multiple cars.

Effect neighborhood mobility hubs on car ownership

The effects of hubs on car ownership is discussed in multiple literature studies. The study of Knippenberg (2019) (N=80) did research among Hely neighborhood hub users and indicated that 50% of the users are considering to have fewer cars in their households. The study showed that a mobility hub is mainly seen as a replacement of owning a second car. This is confirmed by the study of Van Rooij (2020), which did research on Hely hubs and indicated that the 'first' car of the household will remain. Research of Nijland, Van Meerkerk, and Hoen (2015) indicates that the majority of shared mobility users who dispose their car are of the classic 'station-based' sharing variant. Research of Van Rooij (2020) indicated that 11% of the hub users decreased their car ownership. Moreover, 33% of the users sold or did not buy an (extra) car. Subsequently, a study in Würzburg concluded that around 15% of the mobility hub users who had access to a private car relinquished a car Pfertner (2017). The first results thus are positive, however most travelers still prefer a private car above shared vehicles.

It is noticeable that in multiple studies the total number of car trips increased, after the hub was introduced (Van Rooij, 2020). Reason for this may be that the shared car is the most used type of mobility of the neighborhood hubs: 75% of the trips made by the hub users was by a shared e-car (Van Rooij, 2020). Besides, 20% of the trips that users would normally make with their own car, is made with an e-car from the hub. Knippenberg (2019) confirms this: in his study 79% of all trips were made by the car. To really reduce car ownership and car trips, Van Rooij (2020) indicates that neighborhood mobility hubs should be part of a greater mobility plan.

The results of the stated choice studies are more positive: a Dutch study showed that almost one-third of hub-users would give up their car (Franken, 2021). The research showed that car ownership in a sub-urban area decreased from 1 car per household to 0.68 cars per household because of the introduction of a hub (decrease of 32%). The paper of Claasen (2020) indicated that mobility hubs could potentially reduce household car ownership by 19.3% in the Hague, and with 13.2% in the lower density areas of Ypenburg and Leidschenveen. A not surprisingly notion is that older people and frequent car users are less likely to relinquish a car, while frequent train users are more likely to get rid of the car.

3.1.5 Neighborhood mobility hub users

Since (potential) hub users are one of the key aspects of this study a literature study is executed to specify the user characteristics which (potentially) will make use of neighborhood mobility hubs. In Table 9 an overview is given of the characteristics found in literature. The table is based on research of Vianen (2022) into neighborhood mobility hubs. The table is modified and some characteristics and references have been added. Since the amount of literature regarding neighborhood is very scarce, also search terms related to user group characteristics of mobility hubs is included. Most of the literature found on mobility hubs consists of theses. The articles indicate that a younger user group is more likely to use hubs, as they are more used to the shared economy (Van Rooij, 2020). However, it has been discovered that senior persons are easier to attract as users when the correct motives in terms of parking pressure or cost benefits are present (Bösehans et al., 2021; Van Rooij, 2020). The parking pressure can be also be seen as a reason that the *potential hub user* lives in higher density urban areas (Van Rooij, 2020).

Table 9: Potential hub user group characteristics for mobility hubs, modified from Vianen (2022)

Potential hub user group characteristic	**Source**
Younger people	Claasen (2020); Van Rooij (2020); Knippenberg (2019); Bösehans et al. (2021); Miramontes (2018)
High level of education	Knippenberg (2019); Bösehans et al. (2021); Miramontes (2018)
Certain level of disposable income	Claasen (2020); Van Rooij (2020)
Green and sustainable mindset	Claasen (2020); Van Rooij (2020); Bösehans et al. (2021); Kreemers et al. (2021)
Already show (multimodal) travelling with sustainable modes	Knippenberg (2019); Bösehans et al. (2021); Claasen (2020); Kreemers et al. (2021)
Relatively low private car-ownership	Knippenberg (2019); Van Rooij (2020)
Experience with shared mobility	Kreemers et al. (2021); Van Rooij (2020)
Lives in a high density urban area	Claasen (2020); Van Rooij (2020)
Living together with family (partner and/or children)	Van Rooij (2020); Knippenberg (2019); Bösehans et al. (2021)
Elderly people, given the right motivation	Van Rooij (2020); Bösehans et al. (2021)
Frequent use of PT	Claasen (2020)
Gender: mostly males	Miramontes (2018)

Because of the scarcity of literature regarding mobility hubs, an overview is made of user group characteristics of shared transport in general (Table 10). Many similarities can be found in the characteristics of hub user and users of shared transport, which is not surprising since the means of transport are the same. The most common personal characteristics are related to age, education level, green and sustainable mindset and frequent usage of PT. The frequency of use of public transport appears to be of great importance. According to Zijlstra et al. (2019), PT users can be seen as early adapters of MaaS. Public transport users, together with bicycle users are those who more often take upon the sharing services (Liao & Correia, 2019; Zijlstra et al., 2019). However, the article by Alonso-González et al. (2020) indicates that not all public transport users have a positive feeling about shared transport. Shared transport might not be affordable for all current public transport users, when making a connection with the amount of income of PT users. A notable characteristic is travelling by plane: Zijlstra et al. (2019) found that the number of flights made in a year contributes to the use of MaaS. People who fly more often have a greater need for travel information, are mainly multimodal travelers and have a stronger preference for technology-driven innovations, all of which contribute to the use of MaaS. Moreover, a clear trend can be seen with regard to concerns about the environment: people with a higher environmental awareness have an above-average strong interest in shared transport or MaaS (Sytsma & Stulen, 2018; Zijlstra et al., 2019).

Table 10: Potential hub user group characteristics regarding shared mobility, modified from Vianen (2022)

Potential user group characteristics shared transport	Source
Previous experience with shared modes	Arendsen (2019)
Higher income households	Claasen (2020)
Younger people;	Arendsen (2019) Winter, Cats, Martens, and van Arem (2020); Claasen (2020); Zijlstra et al. (2019); Sytsma and Stulen (2018); Jittrapirom et al. (2017); Alonso-González et al. (2020)
Green and sustainable mindset	Claasen (2020); Zijlstra et al. (2019); Sytsma and Stulen (2018)
High level of education	Arendsen (2019); Winter et al. (2020); Zijlstra et al. (2019); Alonso-González et al. (2020)
Frequent use of PT	Zijlstra et al. (2019); Ho, Hensher, Mulley, and Wong (2017); Alonso González, Van Oort, Cats, and Hoogendoorn (2017); Jittrapirom et al. (2017)
Travelling by plane	Zijlstra et al. (2019)
Gender: little more males	Zijlstra et al. (2019)
Reliance on the bicycle in daily lives	Zijlstra et al. (2019)
Lives in a high density urban area	Zijlstra et al. (2019)
Higher income households	Alonso González et al. (2017)

In Table 11, the user group characteristics specified per mode are shown. The entire table including references can be found in Appendix C. The user profile for different modes of shared mobility services are different but share some traits: younger people, mostly living in a higher density urban area, with high education and often having an higher income. In general, most users are concerned with environmental issues and have a green and sustainable mindset. Regarding their previous (or current) travel behavior most users already travel using (multimodal) sustainable modes, are often frequent public transport users and have a limited access to a car.

Table 11: Potential hub user group characteristics, specified per mode

	Shared cars	Shared (e-)bikes	Shared mopeds	Shared scooters	Shared cargo bikes
Lives in a high density urban area	x	x	x	x	
Younger people	x	x	x	x	x
High level of education	x	x	x		x
Higher income households	x	x	x		
Green and sustainable mindset	x	x		x	x
Already show (multimodal) travelling with sustainable modes	x	x		x	x
Low private car-ownership	x	x		x	
Gender: mostly males	x	x		x	
Other:	Single households and households with younger children	White ethnicity		Single households	Living together with children
Other:	Elderly people without children	Low private bicycle-ownership		Own private (e-)scooters	Reliance on the bicycle in daily lives
Other:		Experience with MaaS		No driving license	

Conclusion
This section has provided an overview of the state-of-the-art regarding neighborhood mobility hubs. First, the concept of mobility hub was analyzed, discovering its different typologies and functionalities. From this, a definition of a neighborhood mobility hub is derived:

A neighborhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations which are available at walking distance from home. A connection with PT as well as other types of services (mobility and non-mobility related) is possible but not required.

Next, the relationship between MaaS and mobility hubs was explained because of its similarities and complementariness. MaaS is a concept that uses a digital platform which integrates existing and new mobility services and offers the possibility to plan and purchase a door-to-door trip. Mobility hubs are often seen as the physical component of MaaS. The digital platform of MaaS makes the use, planning and purchase of the different transport modes easier while a mobility hub offers a physical platform which improves the access to the services.

Subsequently, an overview is given of all existing mobility hubs in the Netherlands and the types (and mix) of mobility that is offered. All types of transport modes that can be used at a hub, as well as the various sharing-forms that exist were highlighted. Each transport mode has its own sharing forms. For neighborhood mobility hubs it is expected that the station-based sharing form will be used most often.

Since this research focuses on the influence of neighborhood mobility hubs on car ownership, an overview is given of all previous research into the intention to use hubs and the effects of hubs on car ownership. With regard to the studies on the intention to use hubs, some studies give more positive results than others. The general picture is that a number of studies indicate that people find hubs "curious," or a "valuable addition," but the intention/willingness to use relatively low: around 20%. Regarding the effect on car ownership, the reviewed studies indicate that most travelers still prefer a private car above shared vehicles. A mobility hub is mainly seen as a replacement of owning a second car. From the studies into actual effects of a hub on car ownership, 11% - 15% of the hub users decreased their car ownership. Stated preference studies are somewhat more positive, indicating that 13.2% - 32% of the potential users would give up their car because of mobility hubs.

The section has ended with an overview of all (potential) user characteristics of shared transport and mobility hubs. Since this research investigates the potential user groups of neighborhood mobility hubs, an extensive literature study is done into user characteristics related to hubs. Persons which are young, higher educated, have a green and sustainable mindset and which already show (multimodal) travelling with sustainable modes are the most common user characteristics of potential hubs users. Because the research into hubs is scarce, also user characteristics of shared transport have been studied. In general, the user profile for shared mobility are younger people, mostly living in a higher density urban area, with high education and often having an higher income. Most users are concerned about the environmental and have a green and sustainable mindset. Regarding their current travel behavior most users already travel using (multimodal) sustainable modes, are often frequent public transport users and have a limited access to a car.

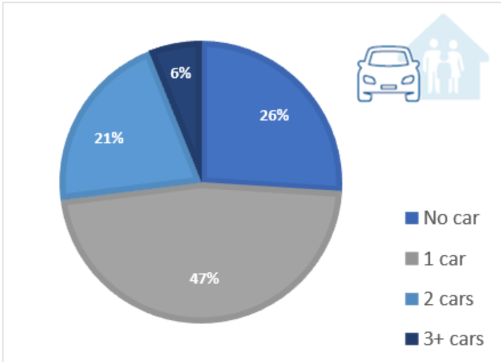
3.2 Car ownership in the Netherlands

To explore the possible effects of a neighborhood mobility hub on car ownership in the Netherlands, a closer view is needed on car ownership in general, car ownership per household and the differences between car ownership in urban areas and rural areas.

Many Dutch people own a car and the number of cars is expected to increase further in the coming years (KiM, 2022a). In 2020, the Netherlands registered 17.4 million inhabitants, 8 million households and 8.7 million passenger cars (KiM, 2022a, 2022b). This is on average just over 1 car per household and 499 cars per 1000 inhabitants. This is less compared to other countries such as Belgium and Germany (Figure 13a). Calculated per squared kilometer of land area, there are no countries having such a high car ownership as the Netherlands has.

Countries	Cars per 1000 inhabitants	Cars per km^2
The Netherlands	499	229
Belgium	511	192
Luxembourg	681	164
Germany	574	133
Italy	663	131
United Kingdom	473	127
Czech Republic	554	75
Denmark	455	61
France	482	59
Sweden	473	11

(a) Comparison of car ownership the Netherlands with close countries in 2019, retrieved from KiM (2022a)



(b) Overview of car ownership per household in 2020 in the Netherlands, retrieved from KiM (2022a)

Figure 13: Comparison of car ownership between the Netherlands and close countries (Figure 13a) and among households in the Netherlands (Figure 13b)

Passenger cars are not evenly distributed among the households (Figure 13b), so an average score per household is not the correct way to investigate the number of cars per household. As can be seen in Figure 13b, more than a quarter of households do not possess a car, 47% of the households own one car and 6% of households own three cars or more. In other words: 450,000 households together have more than 1.5 million cars (KiM, 2022a). All households with more than 1 car together own 56% of all cars in the Netherlands.
Since 1990, car ownership has increased from 0.8 to almost 1.1 car per household (KiM, 2022b). The number of cars is expected to continue to grow, but at a slower pace than in recent years (Figure 14). Car ownership in the Netherlands is anticipated to increase to 502 to 525 cars per 1,000 inhabitants by 2030, according to the PBL (Netherlands Environmental Assessment Agency) (KiM, 2022a).

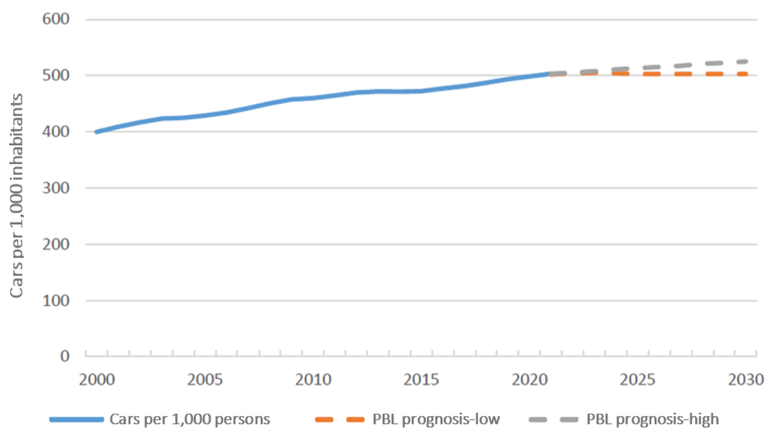


Figure 14: Number of cars per inhabitant in the Netherlands and its forecast, retrieved from KiM (2022a)

The overall picture for the Netherlands is not unambiguous: there is a dichotomy between urban and rural areas. In urban areas, residents are becoming less dependent on owning a car. The reason for this is the shorter distances and proximity to work, attractive public transport connections and the availability of shared cars (KiM, 2022a). Furthermore, it is made less appealing for the car in the city due to limited space, greater (parking) prices and increased road delays. In rural areas, residents are becoming more dependent on the car because facilities and workplaces are disappearing and bus lines are being removed because there is too little demand (KiM, 2022a). Figure 16 depicts the development of car ownership between urban and rural areas throughout time.

Although car ownership (per 1000 inhabitants) is increasing nationally (Figure 14), a trend towards less car ownership is visible in the four major cities (Amsterdam, Rotterdam, The Hague and Utrecht; also known as G4). The number of inhabitants in these cities has grown strongly in recent years CBS (2021a), while car ownership has increased less (CBS, 2021c). Car ownership and use in the G4 are therefore decreasing per inhabitant. In other urban areas and outside urban agglomerations, the population is increasing, as is car ownership (CBS, 2021a, 2021c) (Figure 16). In all G4 cities, a slight increase in car ownership can be seen in 2020. This may be due to the sharp decline in the use of public transport during the corona period and, as a result, more car dependency (KiM, 2021a).

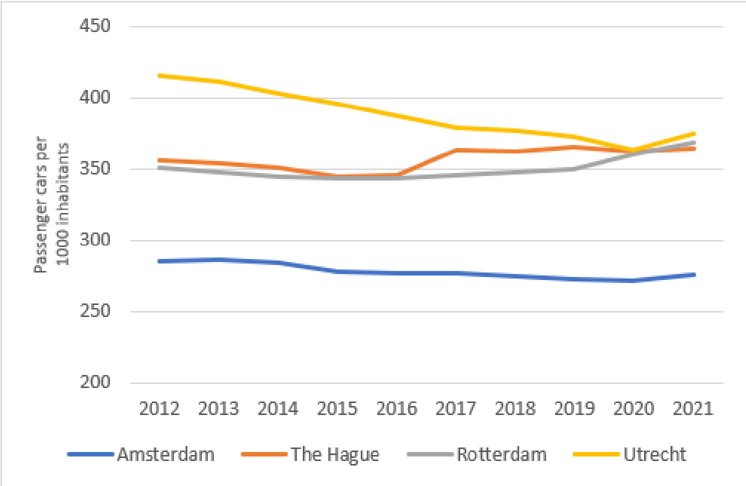


Figure 15: Car ownership in G4 on 1st of January in 2012-2021, retrieved using data from CBS (2021a, 2021c)

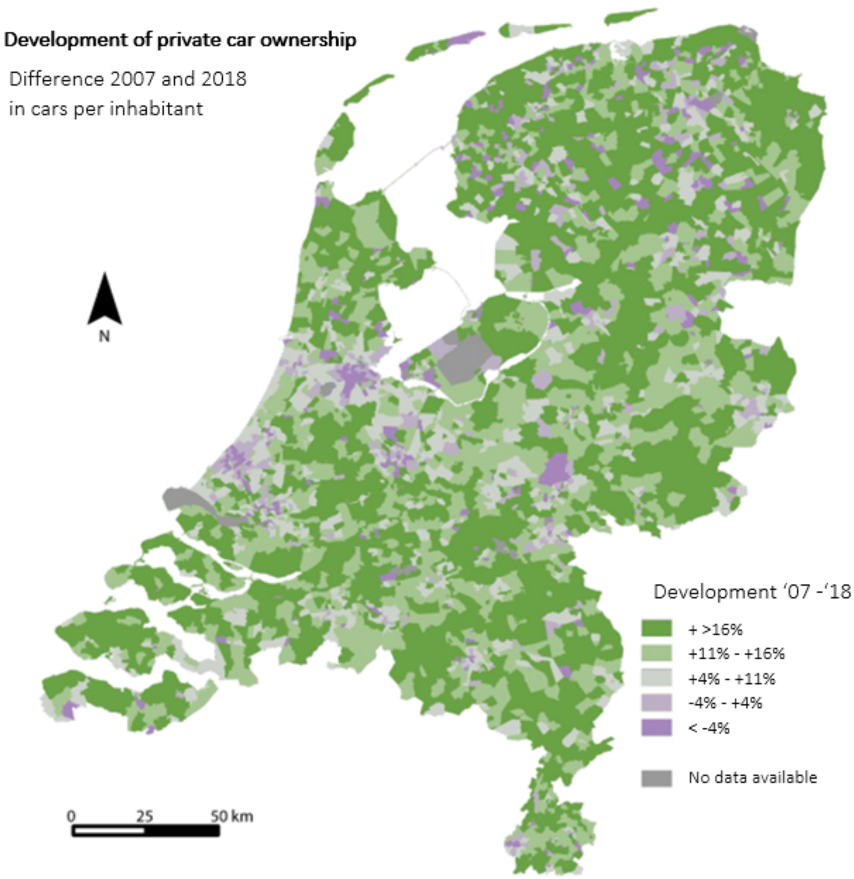


Figure 16: Car ownership in the Netherlands in the period 2007-2018, retrieved from KiM (2022a)

Conclusion

This section gave an overview of the development of car ownership in the Netherlands. In total 8.7 million passenger cars are registered in the Netherlands, which accounts for 499 car per 1000 inhabitants. When looking at number of cars per household 26% of the Dutch households have no car, 47% own one car, 21% owns two cars and 6% of the households own 3 cars or more. In the coming years, the number of cars is expected to rise to approximately 502-525 cars per 1000 inhabitants in 2030 on national level. A dichotomy can be seen between rural and urban areas in the Netherlands. In rural areas people are becoming more car dependent, because of the decreasing accessibility of e.g. bus lines. When looking at the G4 countries, another trend is seen towards a lower car ownership per 1000 inhabitants. This is among others caused by attractive PT connections, sharing services, parking problems and congestion on the road.

3.3 Theories on adoption of technologies

To make a well-considered choice between the existing adoption theories, an overview is given on the existing theories related to the adoption and acceptance of innovations. The success of the implementation of a mobility hub depends on the adoption pattern of individuals (Straub, 2009). Adoption theories explain the individual and its choices she/he makes to accept or reject a particular innovation.

Theory of Reasoned Action and Theory of Planned Behavior
There are multiple theories available in literature on how people make decisions in order to intent to use an innovation (a new product or service; here: mobility hubs). Regarding the intention to use mobility hubs, the focus lies mainly on the behavioural aspect of users. The Theory of Reasoned Action (TRA) tries to explain and predict the relationship between attitudes and behaviours within human action, assuming people have a free choice (Fishbein & Ajzen, 1980). Its main goal is to predict how persons make a decision based on their pre-existing attitudes and behavioural intentions (Ajzen, 2011). The Theory of Planned Behaviour (TPB) is an extension of the Theory of Reasoned Action, by including the aspect 'perceived behavioural control'. This theory explains that the choice is also dependent on the individual's perception of its ability to execute a certain behaviour, which makes it possible to explain the choice of travel mode (Manstead & Parker, 1995). The Theory of Planned Behaviour is a theory that states that (behavioural) intention is the most important factor for behaviour and that intention follows from three factors: attitude to behaviour, subjective norm and perceived behavioural control (Figure 17). According to Granić and Marangunić (2019), a restriction of the theory is that it is based on the belief that individuals make decisions based on the available information. This excludes behavior based on unconscious motives.

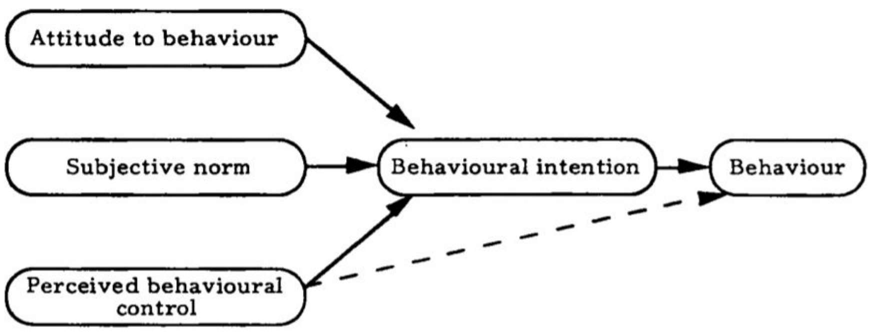


Figure 17: Theory of planned behaviour, retrieved from Manstead and Parker (1995)

Technology Acceptance Model
The Technology Acceptance Model (TAM) (Figure 18) is designed to measure the adoption of new technology based on users' attitudes (Straub, 2009). TAM is introduced by Davis (1989) and based on the Theory of Reasoned Action. TAM shows which factors influence people's intention to actually use a product. The Technology Acceptance Model argues that the adoption rate of a product does not solely depend on the features it has, but assumes that individual's behavioral intention to use a technology is determined by perceived usefulness and perceived ease of use. Moreover, perceived ease of use also influences the perceived usefulness (Figure 18). According to Davis (1989), perceived usefulness is the extent to which a person believes that using a particular system would enhance his or her job performance. Perceived ease of use, in contrast, refers to the degree to

which an individual believes that using a particular system would be free of effort. The model states that both factors can in turn be influenced by external factors, such as social norms, recommendations from friends and background knowledge. Eventually, the behavioral intention to use a technology is found to be the most important determinant for the actual behavior.

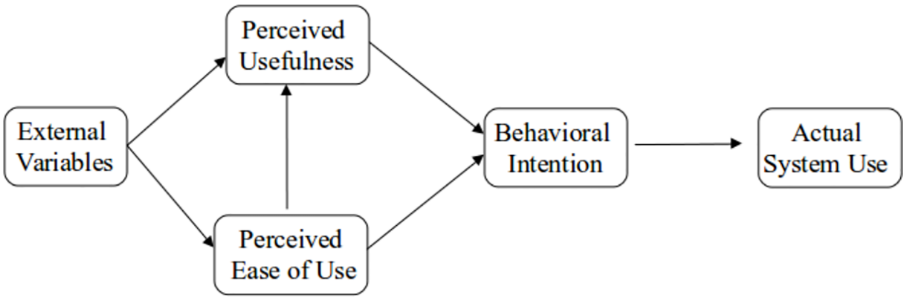


Figure 18: Technology Acceptance Model, retrieved from Davis (1989)

The main strength of TAM over TPB and TRA is its simplicity. It reduces the number of variables that predict whether a user will accept a new technology to two: perceived usefulness and perceived ease of use (Lee, Kozar, & Larsen, 2003). Furthermore, TAM purposefully excludes the social factor from the dependent variables. Using the TRA it was very difficult to determine exactly what a person is thinking and feeling (Davis, 1989). Because this part is left out in TAM, the model is easier to implement and less complicated research is needed to get an outcome of the model. There are also some criticisms about the Technology Acceptance Model. First of all, TAM was found to be suitable for predicting system usage behavior, but unable to identify the reasons behind perceived ease of use or perceived usefulness (Bagozzi, 2007). When the model indicated that the technology was not accepted by the users, reasons for the rejection were not given. In addition, TAM is a model that primarily focuses on individual acceptance or rejection of systems. The problem here is that TAM only looks at adoption and not at diffusion (Lucas, Swanson, & Zmud, 2007). Adoption is about an individual's decision to use a particular innovation, while diffusion is about the joint use of an innovation (Rogers, 2002).

Diffusion of Innovation (DOI) theory

As mentioned a few lines earlier, the TAM model describe how individuals make choices to adopt an innovation (Rogers, 2002). The Diffusion of Innovations (DOI) theory is different in a sense that it explains the adoption process of an innovation through the general population over time (Rogers, 1995). According to Rogers (1995), five elements influence the diffusion of an innovation during time: the innovation itself, adopters, communication channels, time and a social system. The theory, which is visualized in Figure 19, assumes that the diffusion of an innovation usually occurs gradually, with some segments of the population adopting the innovation early (the innovators, early adopters, and early majority) and others only adopting it once it has become the new norm (late majority and laggards).

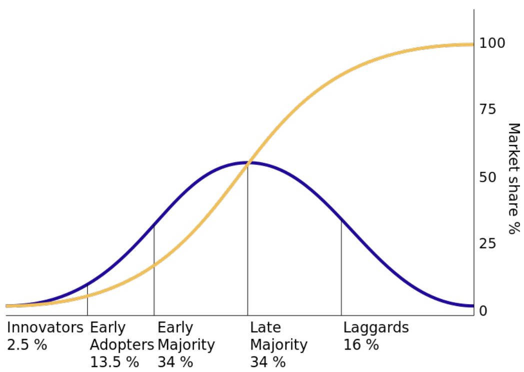


Figure 19: Diffusion of Innovation, from Rogers (1995), adapted from Bösehans et al. (2021)

Furthermore, DOI theory proposes five characteristics of an innovation: relative advantage (the extent to which an innovation is seen as better than its predecessor), compatibility (the extent to which an innovation is seen as compatible with the existing norms, values and needs of a person), complexity (the degree to which an innovation is perceived as difficult to use), trialability (the degree to which the innovation has been experimented with) and observability (the degree to which the results of an innovation can be seen by others) (Moore & Benbasat, 1991). These characteristics can be used to predict the adoption potential of new innovations. According to Wu and Wang (2005), relative advantage and complexity can be compared one-to-one with TAM's perceived usefulness and perceived ease of use. Rogers's Diffusion of Innovation theory has influenced many other research of adoption and diffusion, among which TAM and the UTAUT(2) model(s) (see next section) are examples (Straub, 2009; Venkatesh, Morris, Davis, & Davis, 2003; Venkatesh et al., 2012).

Unified Theory of Acceptance and Use Technology model

A review study of Venkatesh et al. (2003) examined eight of the most common theoretical frameworks used to understand the individual adoption and use of technology. This resulted in a unified model for understanding technology acceptance: the Unified Theory of Acceptance and Use of Technology (UTAUT) model. The UTAUT is one of the most comprehensive technology acceptance models and besides being the most common extension of the Technology Acceptance Model, the model is also based on the Theory of Reason Action, Theory of Planned Behavior and the Diffusion of Innovation Theory (Straub, 2009; Venkatesh et al., 2003). The original model assumes that a person's behavioral intention to use a technology is influenced by performance expectancy (degree to which the technology is perceived to be useful), effort expectancy (the perceived ease of use) and social influence (degree to which using the technology is appreciated in the social network important to the individual), whereas the construct facilitating conditions (degree to which the individual believes to be in control of the resources to use the technology) determines the use of technology (Venkatesh et al., 2003).

According to Venkatesh et al. (2003), the UTAUT model is able to explain up to 70 percent of the variance of individual intention to use a technology. The authors stated that this percentage may be at the limit of what is possible in explaining the construct behavioral intention. It can be concluded from the results of Straub (2009) and Venkatesh et al. (2003) that UTAUT is a good basis for the acceptance of a new technology among (potential) users.

Despite the fact that the UTAUT model being widely accepted Ye, Zheng, and Yi (2020) and Venkatesh et al. (2012) extended the model in 2012 resulting in the UTAUT2 model (Figure 20). UTAUT2 shows that, in addition to the UTAUT constructs, the intention to use the technology is influenced by hedonic motivation, price value and habit. Hedonic motivation is explained by the degree to which the technology is perceived to be enjoyable, price value is the trade-off between perceived benefits and monetary costs of technology usage and habit is defined as the passage of time from the initial technology usage (Venkatesh et al., 2012). At the bottom of the model in Figure 20 three moderating factors are present: age, gender and experience. The factors either strengthen or weaken a determinant, depending on the input to that factor (Venkatesh et al., 2012). The study found that not every moderator had an effect on the relationship between an indicator and intention to use or usage behavior. Due to these additions, UTAUT2 is more focused on consumer technology, compared to the UTAUT model (Venkatesh et al., 2012).

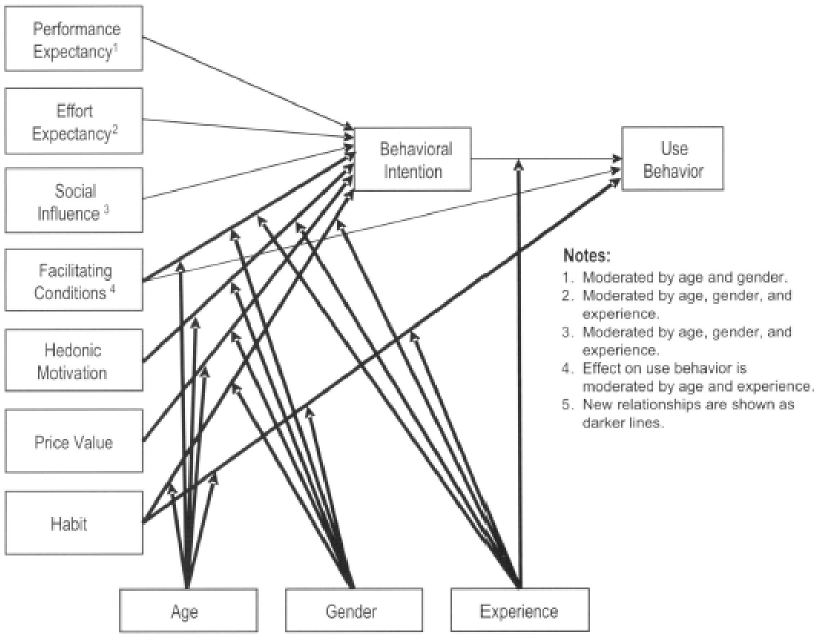


Figure 20: UTAUT2 model, retrieved from Venkatesh et al. (2012)

UTAUT2 builds upon UTAUT as a good predictor of intention to use a technology. Venkatesh et al. (2012) concluded in their research that UTAUT2 could explain 74 percent of the variance for Behavioral Intention. The model uses much of the same constructs as UTAUT, which has already proven its validity (Straub, 2009; Venkatesh et al., 2003). By leaving the business-oriented determinants out and adding the determinants in the consumer field, this is the appropriate model for studying the adoption of a technology among customers (Venkatesh et al., 2012).

For this research, the UTAUT2 model has been chosen as most suitable model and will be used as a basis for the conceptual model. The UTAUT2 model is chosen because it builds upon eight proven technology acceptance models (Venkatesh et al., 2012), it has high prediction accuracy (Venkatesh et al., 2012) and has a focus on consumer technology, which was not accounted for in the UTAUT model (Straub, 2009). This makes the UTAUT2 model highly suitable for researching the adoption of shared transport offered by neighborhood mobility hubs. In the next section, the conceptual model will be explained thoroughly.

Conclusion

This section provided an overview of the theories related to the adoption and acceptance of technologies. Multiple theories have been discussed, all consisting of their own strengths and weaknesses. In this it is noticeable that the latter two theories, UTAUT and UTAUT2, are built upon the theories discussed before, which results in a high prediction accuracy of the behavioral intention to use a technology. In the end of the section, a well-founded choice was made for the UTAUT2 model as a basis for the conceptual model.

3.4 Conceptual model

In this section, the UTAUT2 model will be adapted to neighborhood mobility hubs and subsequently factors affecting the intention to use mobility hubs will be investigated. The conceptual model can be found in Figure 21. As can be seen, eight indicators and eleven moderators are expected to influence the intention to use mobility offered by mobility hubs. A search was done in literature for the relationship between the initial indicators of the UTAUT2 model and the intention to use (neighborhood) mobility hubs. Since the concept of hubs is relatively new in academic literature, also search terms in the direction of MaaS and shared mobility are used to substantiate the possible relationship. The conceptual model differs from the UTAUT2 model in that the construct habit and the latent variable use behavior are not included. Besides, two constructs are added which might influence the behavioral intention to use hubs: environmental concern and individual innovation. First, the indicators and latent variable not included in the conceptual model will be explained. Thereafter, a detailed description is given of the chosen constructs and their relationship with the intention to use hubs.

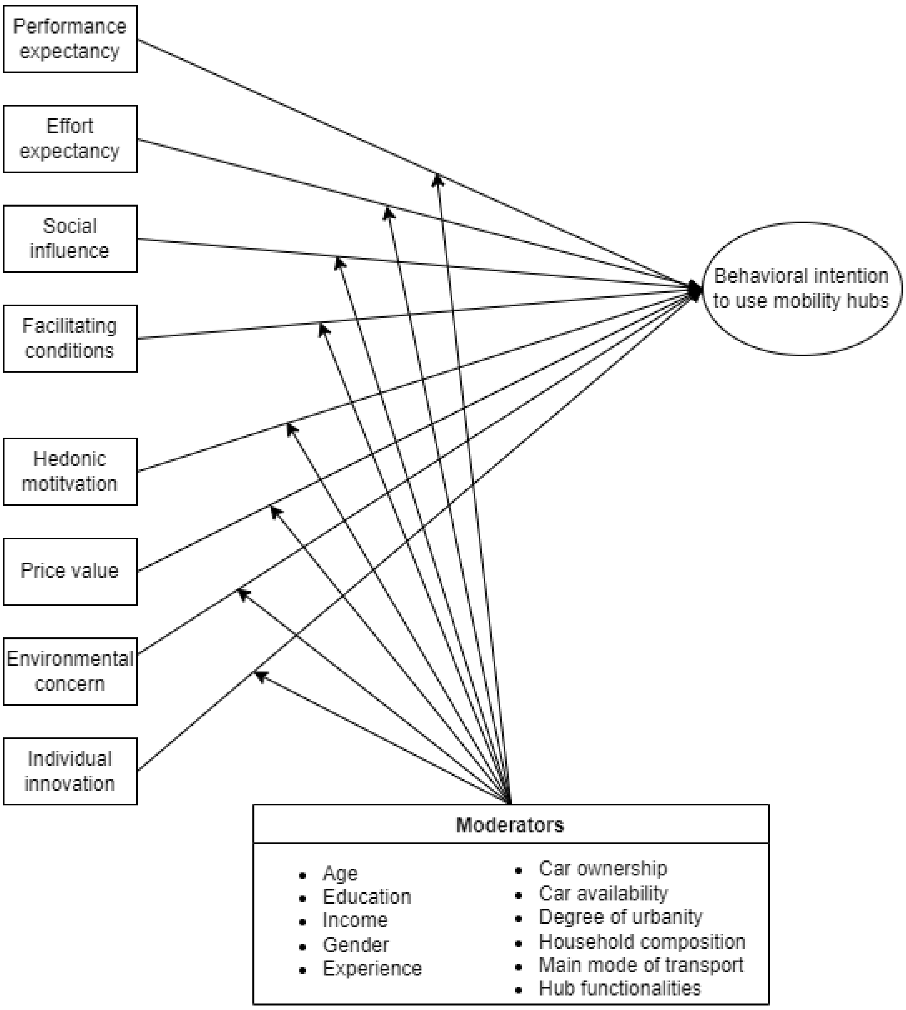


Figure 21: Conceptual model for this research regarding the intention to use mobility offered by mobility hubs

It is decided to not include **habit** in the conceptual model. Habit was added as an extra construct, when the UTAUT2 model emerged from the UTAUT model. Habit is seen as prior behavior and is measured as the extent to which an individual believes the behavior to be automatic (Venkatesh et al., 2012). The reason not to include habit is because mobility hubs are a recent innovation in the introduction stage of the Product Life Cycle (Figure 19), which is used mainly by the 'innovators' (Bösehans et al., 2021). For this reason, mobility offered by mobility hubs has not yet gained sufficiently widespread use among users to generate a habit.

Moreover, for this research it is more appropriate to measure behavioral intention than use behavior. **Use behavior** is defined as the use behavior measured from the actual frequency of using a technology (Venkatesh et al., 2003). Since mobility hubs are not yet implemented in the Netherlands on large scale and most users are still in the innovators stage, the measuring of usage behavior is not possible. Estimating a person's usage behavior when the technology in question is not yet available throughout the research area may lead respondents to predict their usage behavior differently than it actually would be (Van 't Veer, 2021). This is not desired, and therefor use behavior will be excluded which makes behavioral intention the dependent variable of the conceptual model.

Indicators
Below, the eight indicators which are expected to influence the intention to use neighborhood mobility hubs are described in detail.

Performance expectancy is defined by Venkatesh et al. (2003) as a degree to which a person believes that using new technology can improve his or her performance. In case of shared vehicles by mobility hubs, performance expectancy refers to the match between system features and travelers' expectations, implying that the traveler perceive benefits from sharing vehicles. These benefits can be expressed among others in travel time and convenience over other transport modes (Koopmans, Groot, Warffemius, Annema, & Hoogendoorn-Lanser, 2013). Access and egress travel time for shared transport may lead to extra travel time, compared to the use of a private car. Research of Tingen (2019), which investigated carsharing in Utrecht, found that decreasing the walking time to shared cars would make carsharing more attractive. Moreover, travel time might differ from using private vehicles, when taking into account reservation of the vehicle. In terms of convenience, KiM (2015) found that one of the motives to use shared cars is because of the parking problems in the neighborhood. On the other side, mobility hubs may also lead to inconvenience in terms of above mentioned access and egress travel time. Stasko, Buck, and Oliver Gao (2013) did research into carsharing users' preference and showed that a carsharing system can help travelers enjoy their journey, save them time and meet their car needs, which in turn can improve their performance. It is also worth emphasizing that a mobility hub contributes to convenience by offering multiple types of shared transport within one application and offered at one place in the neighborhood. To sum up, the term performance expectancy of mobility hubs is measured using *travel time and convenience* in comparison with other transport modes. Fleury, Tom, Jamet, and Colas-Maheux (2017) concluded that performance expectancy is a determined factor for predicting users' intention to adopt a carsharing system. This is also confirmed by the study of Liang, Jin, and Jiang (2018) conducted in China; they observed that a travelers expectation of the systems performance is a crucial predictor of the intention to use carsharing. In case of bicycle sharing, Huang and Chen (2017) argues that performance expectations play an important role in shaping individuals' usage intention towards bicycle-sharing. An important notion is that travelers have a stronger intention to use bicycle sharing systems, when they perceive that it is useful in daily life and helps them to perform activities (Chen & Chancellor, 2020; Chopdar, Lytras, & Visvizi, 2022). Taking past research about carsharing and bikesharing into account, it is expected that performance expectancy is deemed to be of influence on the intention to use mobility hubs.

Effort expectancy, also called ease of use in the TAM model, refers to the perception that using neighborhood mobility hubs is free from effort (Venkatesh et al., 2003). Ways to achieve this ease of use is by offering a system which is easy to use for everyone; by lowering the threshold to use it (Claasen, 2020). One way to do this is by ensuring that enough vehicles are available within the close neighborhood. Research of Kreemers et al. (2021) found that the availability of a mobility hub nearby was an important reason to try out that hub. The use of shared mobility is related to the use of smartphone technologies, such as making a reservation before use and technologies within a vehicle. When shared mobility is easy to use and easy to interact with, a travelers' intention to use will be increased (Tran, Zhao, Diop, & Song, 2019). Research of Tran et al. (2019) tested the relationship between effort expectancy and behavioral intention in case of electric carsharing in China, which was found to be a significant positive relationship. Previous study of Fleury et al. (2017) on carsharing proved that effort expectancy is one of the most important determinants of intending to use carsharing.

The indicator **social influence** is expected to influence the intention to use hubs. Social influence is defined as the degree to which an individual perceives that (important) others believe he or she should use mobility offered by mobility hubs (Venkatesh et al., 2003). This may concern friends and family, but also (local) newspapers or other forms of media attention. The study of Claasen (2020) found that the likelihood of an individual using shared transport provided by a hub increases if other persons close to that individual makes use of a mobility hub. Besides, the findings of Kreemers et al. (2021), investigating neighborhood mobility hubs in Leuven and Amsterdam, indicate that car owners perceive trying out hubs as more useful when people in their immediate environment were positive about using the hubs. This is supported by the research of Burghard and Dütschke (2018), showing that the a travelers' willingness to use shared mobility depends on prevailing social norms.

Facilitating conditions refers to the degree to which a person believes to be in control of the resources to use the technology (Venkatesh et al., 2003). It has been decided to narrow the definition using Ye et al. (2020), by focusing on the technical conditions needed to use a mobility hub. These conditions are the skills that individuals have with their smartphones, the stability of the mobile network and the familiarity of individuals with mobile payments. These conditions are of importance for the use of hubs: research of Kreemers et al. (2021) indicated that the smartphone usage and the hassle of figuring out how a mobility hubs works were barriers of using the hub. The study of Horjus (2021) looked into the potential use of shared mobility at a PT hub in the Hague and stated that the intention to use shared mobility is higher for individuals experiencing higher levels of digital skills. Moreover, research of Van 't Veer (2021) into car owners' intention to make use of MaaS shows that facilitating conditions is expected to influence behavioral intention to use MaaS in the Netherlands. This is confirmed by Fleury et al. (2017), which examined corporate car sharing in France and found that facilitating conditions had a positive effect on the intention to use car sharing. These findings result in the decision to include facilitating conditions into the conceptual model, by indicating that a higher degree of facilitating conditions will lead to a higher intention to use hubs.

Hedonic motivation is defined as the fun or pleasure derived from using a technology (Venkatesh et al., 2012). The relationship between hedonic motivation and behavioral intention has been shown in numerous previous research on technology acceptance (Madigan, Louw, Wilbrink, Schieben, & Merat, 2017; Tran et al., 2019). The study of Madigan et al. (2017) found that the fun and entertainment that travelers get from using a particular transport mode leads to increased intention to use. Looking at hub-related literature, Kreemers et al. (2021) investigated hedonic motivation as a construct of perceived usefulness, and found that people experienced feelings of pleasure when driving electric shared cars. This contributed to the perceived usefulness of trying out a neighborhood hub, which in turn was a strong determinant of the intention to use hubs. The study of Claasen (2020) indicated that people having a positive attitude toward shared cars would prefer the use of mobility hubs, whereas the individuals already owning a car are less interested. Research of Tran et al. (2019) into electric carsharing confirmed that one of the most important factors that potential users will consider when deciding to use carsharing is whether they believe that using it will be fun and enjoyable. Besides shared cars, some interviewees of the study of Kreemers et al. (2021) indicated that they would consider the use of other shared e-mobility as a fun activity, such as a bicycle tour. Thus, it is expected that travelers with a positive hedonic motivation towards shared mobility offered by a hub are more likely to have positive intention to use the new system.

Furthermore, it is decided to include **price value** in the conceptual model for this research. According to Venkatesh et al. (2003), price value is the trade-off between perceived benefits and monetary costs of technology usage. Benefits might include monetary savings, health benefits and flexibility (Chopdar et al., 2022). Moreover, users may experience less anxiety about theft or vandalism and perceive the benefits of no maintenance cost and no parking restrictions or charges (Curto et al., 2016). Costs are an important factor related to the beneficial of mobility hubs compared to other means of transport. According to Kreemers et al. (2021), perceived costs are an important reason for car owners *not* to try out mobility hubs. What strikes is that most of the investigated car owners compared the costs of fuel with the use of a mobility hub and forgot about other car related costs, such as insurance and road tax. This is confirmed by the research of KiM (2018a), which indicated that car owners often underestimate their total travel costs made by car. It differs per study whether price value has an impact on the intention to use an innovation. Interestingly, the majority of the studies regarding price value and intention to use shared transport focused on bicycle sharing. A study of Jahanshahi, Tabibi, and van Wee (2020) into a bicycle sharing system in Iran, found that behavioral intention was not predicted significantly by price value. On the other hand, a study of Chen and Chancellor (2020) found that price value had a significant relation with bicycle sharing intentions. Moreover, the study of Du and Cheng (2018) regarding free floating bicycle sharing in China indicated that price is a crucial variable affecting the usage of bicycle sharing. People were more inclined to use bicycle sharing when prices were reasonable. This is confirmed by the study of Kreemers et al. (2021) which found that one of the most often mentioned reasons to try out mobility offered by a hub (in Amsterdam and Leuven), was the possibility of attractive pricing. It is expected that, given that mobility hubs are still in the innovator stage (DOI model, Figure 19), prices will remain somewhat low for the time being. The same can be seen for MaaS technologies. In the article of Zijlstra, Durand, Hoogendoorn-Lanser, and Harms (2020) regarding MaaS, the growth of consumer prices within MaaS is viewed as unexplored area, with no expectations of changes in the near future. Because of the early adopter phase of MaaS technologies, high prices will hinder the spread of MaaS and is therefore unlikely. The same may happen for mobility hubs, since it is often seen as the physical component of MaaS (KiM, 2021c). It is therefore expected that price value will be a determinant for the intention to use mobility offered by mobility hubs.

Environmental concern is a newly added construct to the model, and refers to the awareness of consequences or effects held by an individual on environmental problems (Fujii, 2006; Schultz et al., 2005). Based on the existing hubs in the Netherlands (see Appendix B), it is expected that shared mobility offered by mobility hubs will mainly be electrically powered. This may be a reason for travelers to intent to use hubs, because people which are environmental conscious have stronger sustainable motivations (Liang et al., 2018), and are more willing to participate in environmentally friendly activities (Gleim & J. Lawson, 2014). This is confirmed by the studies of Burkhardt and Millard-Ball (2006) and Costain, Ardron, and Habib (2012), which indicated that carsharing users were environmentally aware and willing to choose environmental friendly mobility alternatives. Research of Alonso-González et al. (2020) found that persons which were less likely to adopt MaaS, concerned less about the environment in their travel behavior. The study of Kreemers et al. (2021) found that the environmental concern was applicable to some of their respondents to try out mobility offered by a hub. It is assumed that sustainable motivation of travelers is an important factor affecting their participation in sharing intentions, so that a higher level of environmental concern increases the intention to use mobility offered by hubs.

Lastly, the indicator **individual innovation** is added to the conceptual model. Individual innovation is mentioned by Ye et al. (2020), and is the ability of an individual to be good at discovering and accepting new technologies. It is assumed that highly innovative users are more open to new technologies and changes compared to less innovative users, which are more reluctant to change and tend to be more negative about new technologies (Back, 2021). There are indications that the degree to which individuals are open to novelty is a predictor of their likelihood to adopt new technological services (Rogers, 2002), while the degree of innovativeness of users has a positive effect on the adoption behavior of an innovation (Leicht, Chtourou, & Ben Youssef, 2018). Individual innovation is expected to influence the adoption of mobility offered by hubs. The study of Back (2021) found that there exist a relation between individual innovation and behavioral intention, indicating that the willingness to use MaaS exists to travelers who are more open to innovation. An interesting finding here is that car users have a greater possibility to embrace MaaS than PT users. This is confirmed by the study of Ye et al. (2020) which indicated that a stronger individual's innovation contributed to a higher willingness to use MaaS. Moreover, the authors found that individuals who are curious and innovative for new things tend to have stronger behavioral willingness. This curiosity was also found by Kreemers et al. (2021) as a reason to try out mobility from hubs.

Moderators

In total, 11 moderators are added to the conceptual model. A moderator influences the strength, direction, or presence of a relationship between a predictor and a variable (Sharma, Durand, & Gur-Arie, 1981). In case of the conceptual model, each moderator is expected to influence the relationship between a constructs and the intention to use. The study of Venkatesh et al. (2012) indicated that not every moderator is expected to have an effect on the relationship between an indicator and intention to use or usage behavior. As a result, all moderating effects are tested, so effects (or moderators) that were initially not in the UTAUT2 model are also taken into account for this study. Eventually, using the LCCA the actual moderating effects will be discovered. Below, the moderators are explained in detail.

Age is expected to influence the intention to use hubs. According to Venkatesh et al. (2003), age differences are believed to have an impact on technology adoption behavior. Research of Miramontes (2018) on actual hub users in Munich and of Knippenberg (2019) on hub users in the Netherlands both indicated that most hub users are younger adults. According to Horjus (2021) the intention to use shared mobility at a hub is higher for travelers which are younger. Here it is interesting to see that shared e-moped users tend to be younger than the potential users of the shared bicycle and shared car. Moreover, according to Bösehans et al. (2021) which performed a cluster analysis, older potential users groups had the least confidence in using mobility offered by hubs.

The level of **education** is expected to influence the potential use of a mobility hub, indicating that a higher level of education contributes to a better potential use of shared mobility offered by the hub (Bösehans et al., 2021; Horjus, 2021; Liao & Correia, 2019). Knippenberg (2019) and Miramontes (2018) found that the actual hub users have a higher level of education. On the other hand, the study of Van Rooij (2020) mentions that the typical hub user is likely to have a low level of education and a low **income**, which is conflicting. A reason for the income may be that a high income has a positive relationship with car use and car ownership (Franken, 2021), so there is no intention to use shared mobility. For lower incomes there might not be a car or there may be economic reasons to give up the private car. The study of Knippenberg (2019) indicate that also middle and higher levels of income are associated with the usage of hubs. Both education and income are therefor expected to influence the intention to use mobility hubs.

Regarding **gender**, recent study of Liao and Correia (2019) into different sharing services (e-car, (cargo-)bike, scooter) indicate that for each mode of transport most users are men. When looking specifically at mobility hubs in the Netherlands, the study of Van Rooij (2020) also found that the most likely hub users are expected to be men. This corresponds with the article of El Zarwi, Vij, and Walker (2017), indicating that men are more likely to be early adopters of new technologies. Gender differences thus are expected regarding acceptance of mobility hubs.

Kreemers et al. (2021) found that **experience** of car owners with shared mobility had a positive influence in wanting to try out shared mobility offered by hubs. Horjus (2021) also found that the intention to use shared transport at a public transport hub is higher when having prior experience in using shared transport. Experience is included as moderator, and relates to the experience with hubs, any form of shared transport or MaaS services.

Besides having experience with shared modes, travel habits preceding the introduction of shared systems could impact the usage of the new sharing systems (Geurs & Münzel, 2022). According to Liao and Correia (2019), PT users together with bicycle users are more likely to use sharing services. Alonso-González et al. (2020) however does indicate that the income of PT users ensures that MaaS services might not be affordable to all current PT users. An interesting finding from Tsouros, Tsirimpa, Pagoni, and Polydoropoulou (2021) entails that infrequent car users are more likely to use MaaS than users never using a car as dominant mode of transport.
The **Main mode of transport** is added as a moderator to the conceptual model, in order to find out what the effect of users' current mode of transport and their potential hub use is. Besides the main mode of transport, **car ownership** per household and **car availability** are added as a moderators. A study of Knippenberg (2019) shows that a mobility hub is mainly seen as a replacement of owning a second car, which is confirmed by Van Rooij (2020). Research of Claasen (2020) indicated that frequent train users have a higher likelihood of replacing their car by shared transport, instead of older people and frequent car users which have a less likely probability of using shared transport.

It is expected that the **degree of urbanity** will influence the intention to use mobility hubs. Previous research indicates that carsharing users mainly live in high density areas (KiM, 2015). The studies of both Claasen (2020) and Van Rooij (2020) indicate that users of a mobility hub typical live in an urban environment. For all above three studies it applies that the sharing service is often stationed at urban areas, because the demand is higher compared to lower density areas. The degree of urbanity is included as a moderator to the model and the intention to use mobility hubs is expected to be higher in high density areas.

Household composition is expected to influence the intention to use hubs as moderator. In research, there is no clear finding of a typical household composition which potentially will make use of hubs. According to Van Rooij (2020), the most likely hub user is a male, living with partner and children. The study of Knippenberg (2019) on the other hand states that current hub users are mostly living alone or with their partner. Speaking of MaaS, households with two or more children are significantly less likely to make use of MaaS than households with one child or no children (Hoerler, Stünzi, Patt, & Del Duce, 2020).

Lastly, **mobility hub functionalities** are added as a moderator to influence the relationship between the indicators and the intention to use hubs. Mobility hubs may serve the purpose better if they are enjoyable places and not just functional parking places. This research focuses on the mobility offered by hubs, however it is interesting to investigate whether extra functionalities (such as parcel lockers) offered by the neighborhood mobility hubs contribute to a better usage of the mobility offered by the hubs.

Sub-question 2: According to literature, which factors are associated with the intention to use mobility offered by neighborhood mobility hubs?

First a literature study was executed into technology acceptance models, after which the UTAUT2 model was determined to be the best model for addressing the factors associated with the intention to use mobility hubs. The UTAUT2 model is used because it builds upon eight proven technology acceptance models, its high prediction accuracy and its focus on consumer technologies.
After an thorough review of literature on the adoption of 1) new technologies, 2) mobility hubs and 3) shared transport in general, the following factors are expected to influence the intention to use mobility offered at mobility hubs:

- Performance Expectancy
- Effort Expectancy
- Social Influence
- Facilitating Conditions
- Hedonic Motivation
- Price Value
- Environmental Concern
- Individual Innovation

Moreover, the following moderators are expected to influence the relationship between the indicators and intention to use neighborhood mobility hubs: age, education, income, gender, experience, car ownership, car availability, degree of urbanity, household composition, main mode of transport and hub functionalities.

4 Survey design

In this chapter, the design of the survey will be discussed. The main part of the survey is based on the conceptual model, which is discussed in previous chapter. In total, 30 questions were asked about the indicators of the conceptual model. These questions can be found in Table 12 on page 42. Furthermore the survey is made up using socio-demographic questions, mobility related questions and questions regarding potential hub usage and effects on car ownership. The survey was created using Microsoft Forms, and distributed in Dutch and English. Despite the fact that this research focuses on people in the Netherlands, it has also been decided to distribute the survey in English. This allows people to complete the survey who do not speak Dutch, but who do live in the Netherlands. The questionnaire consists mainly of closed-end questions, and two open questions regarding age and postal code.

The survey was distributed in the Netherlands, using online channels, such as Linkedin and Facebook and shared among Witteveen + Bos employees using email. Moreover, flyers were handed out on the streets in the cities Leiden, Utrecht and The Hague on which a QR code was printed to access the online survey. A prize draw was used to stimulate the respondents to complete the survey.

A few pilot versions were tested prior to the launch of the final version of the questionnaire. After a respondent completed the test survey, the comments were discussed and adjusted if necessary. The pilot surveys ensured that the final survey was understandable for all respondents. In total, 12 respondents tested the survey. The group of respondents consisted of a selection of friends, family, members of the thesis committee and colleagues of Witteveen + Bos. The tests resulted in improvements in terms of more readable paragraphs and clearer questions.

Since the survey contains human subjects, certain ethical considerations were taken into account. First, in the introduction to the questionnaire, the purpose of the study was explained and it was made clear to respondents that their participation in the study is completely voluntary and anonymous. Secondly, the respondents were told that they could leave the questionnaire at any time. In addition, the data will remain confidential and will be stored completely anonymized. In case of any questions from respondents when filling in the survey, the researcher's email address was included in the introduction text. No personally identifiable information has been requested to comply with the General Data Protection Regulation (GDPR). To adhere to this, respondents are not asked for the entire postal code, but only for the first four digits. In order to get a chance to win one of the prices, the respondents have the possibility of filling in their email address at the end of the survey. This is detached from the respondents data, and only used to choose the winners. After doing so, the email addresses will be deleted. Prior to the study, permission was requested and granted from the Human Research Ethics Committee of Delft University of Technology (see Appendix E).

4.1 Survey structure

The final survey can be found in Appendix D. In total, 47 questions closed-end questions and 2 open questions were asked. In Figure 22, the structure of the survey is visualized. The survey consists of six parts: introduction, socio-demographic factors, current mobility, introduction of the hub, questions regarding the indicators, and finally questions regarding car ownership and hubs. Below, an explanation of each section is given.

1. Introduction
At the start of the survey, the purpose of the survey and the research is explained to the respondents. Furthermore, the ethical considerations discussed above are mentioned to the participant. The introduction ends with information about the prize draw. The participants will have to leave their email address for this at the end of the questionnaire.

2. Socio-demographic factors
The first questions asked are related to socio-demographic factors. These socio-demographic factors are based on part of the moderators from the conceptual model (Figure 21). The questions focus on gender, age, household composition, educational level, occupation, income and postal code.

3. Current mobility options
The next section starts with a couple of questions regarding mobility and car ownership. The respondents are asked if they have a driver's license, the number of cars that the household owns and to what extent they have

easy access to cars. In order to get a good picture of the current travel behavior of respondents, questions are asked about the use and frequency of different means of transport. This may be valuable later in the report, when entailing the possible relation between users' current travel behavior and potential use of a hub (sub research question 4). This is a relatively simple way to find out the current travel behavior of respondents. Another option is to let the respondents make a travel diary. However, this was not chosen due to the time limit of the survey. To finish the section, a couple of questions are asked regarding the possible use, frequency and experience of multiple types of shared transport. Lastly, the respondent is asked whether they already knew the concept of a mobility hub.

4. Explanation mobility hub
The concept of a neighborhood mobility hub is explained to the respondents prior to the questions about the indicators that are expected to influence the intention to use mobility hubs. Since mobility hubs are a new concept, many people in the Netherlands do not yet know what a mobility hub is. Therefor a description is made up that explains what a mobility hubs is, what type of (electric) mobility is offered at the hub and that a fee has to be paid, that differs per vehicle. An illustration is attached to give respondents a visual impression of a mobility hub.

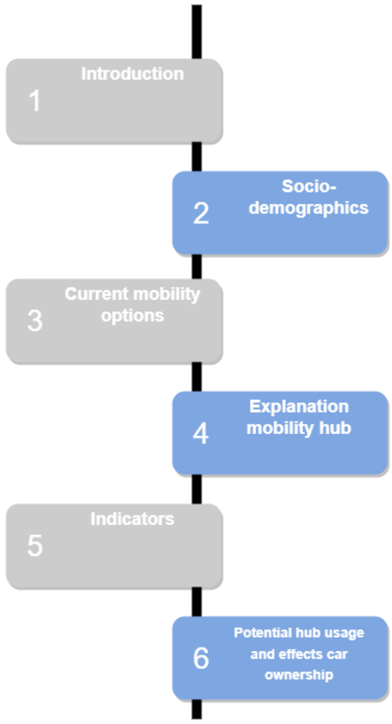


Figure 22: Survey structure

5. Indicators
After reading the explanation about mobility hubs, the questions regarding the indicators are asked. In total 30 statements are asked, which can be answered using a 5 point Likert scale from "completely disagree" to "completely agree". In section 3.4, the indicators relevant for this study has been chosen (underpinned with literature), after which an extensive search has been done to find survey questions related to those indicators. This resulted in the fact that the majority of the statements have been modified from other journals and scientific papers. The statements and their sources can be found in Table 12 and will be explained below. The first five statements are used for the behavioral intention to use mobility hubs, which is not an indicator discussed in section 3.4, but is needed in the LCCA. For the two questions regarding the walking distance to mobility hubs, the paper of Geurs and Münzel (2022) was used as reference. In the paper, a literature overview was given for the recommended walking time and distance to forms of shared transport. The maximal distance differed between 125 and 800 meters, with a maximum walking time of 3 to 5 minutes. Since 800 meters is highly unlikely to be walked within 5 minutes, it is chosen to add an extra walking time of 10 minutes, next to the walking option of 5 minutes. For this thesis, it has been chosen to focus on the type of mobility offered at a mobility hub. A hub however entails more than that. Therefore, a question was asked related to the intention to use hubs and the possibility of extra facilities.

Three statements, preferably, have been considered for each indicator. In previous chapter, **performance expectancy** was explained as the improvement of a technology in terms of travel time and convenience. The statements from the research of Van 't Veer (2021) cover these in terms of making a trip. An additional statement was added from the research of Back (2021) related to the convenience of having a choice of transportation mode. **Effort expectancy**, the ease of use related to the technology is measured using statements of Jain, Bhaskar, and Jain (2021) which are related to the ease of using the hub and making reservations. Furthermore, a statement has been added related to the availability of transport modes, which was found to be an important aspect of effort expectancy discussed in section 3.4. In total, four statements are included in the questionnaire related to **social influence**, of which three were modified from the research of Jain et al. (2021) and Ye et al. (2020). All statements are about the influence of (important) others, such as friends, family and media which might influence the potential usage of mobility hubs. **Facilitating conditions** relates to different technical conditions which are needed to use a mobility hub, by usage of a smartphone. The statements are found in the the research of Ye et al. (2020), which researched the willingness to use MaaS technologies and thus is highly related to mobility hubs. **Hedonic motivation** is measured using three statements regarding the fun and enjoyment a mobility hub might generate. Two of the statements were used from research into the willingness to use MaaS (Schikofsky, Dannewald, & Kowald, 2020; Van 't Veer, 2021) and have been used in past questionnaires. Since mobility hubs (shared mobility in general) most often use electrical vehicles, a question has been added about the enjoyment of using electrical powered vehicles. Two statements have been added regarding **price value**. Ideally, a minimum of three statements per construct was decided on. However, a third statement that was suitable for this research could not be found. Using research of (Van 't Veer, 2021), a statement regarding price expectation was found. Moreover, a willingness to pay statement was conceived by the author. **Environmental concern** is represented by four statements, consisting of the respondents' concernment about the environment, its willingness to reduce CO2 (Kilbourne & Pickett, 2008) and the expectations about the environmental friendliness of a mobility hub (Back, 2021). Lastly, **individual innovation** is measured using statements regarding the curiosity of using a new technology (Ye et al., 2020), the experimentation of using new services (Back, 2021) and the respondents' adaption position related to trying out new technologies (Ye et al., 2020).

6. Potential hub usage and effect on car ownership

In the last section, a situation is sketched supposing that there will be a mobility hub in the respondents neighborhood. The respondent is asked whether they would consider using a shared car, shared bicycle, shared e-bike, shared moped or shared cargo bike, and how often they are likely to use the different modes. Moreover, the respondent is asked whether they would consider to use their car less often because of the neighborhood hub, or to even sell their first or second car. The risk of these questions is that a degree of bias can arise and that the preferences stated may not predict actual behavior (de Corte, Cairns, & Grieve, 2021). Individuals tend to overestimate their valuation of a particular service, which may lead to misleading estimates. This will be taken into account when interpreting the results. The questionnaire was eventually concluded with a statement thanking the respondents and pointing out to fill in the email address if the respondents wants to have a chance of winning one of prizes.

Table 12: Indicators, questions and its references used in the questionnaire

Indicator	Question	Source
Behavioral intention	I think using mobility hubs will benefit me a lot	Back (2021), modified
Behavioral intention	I intend to use mobility hubs, assuming that it would be available in my neighborhood in the future	Schikofsky et al. (2020), modified
Behavioral intention	I intend to use mobility hubs when the walking time to the mobility hub is less than 5 minutes	Schikofsky et al. (2020), Geurs and Münzel (2022)
Behavioral intention	I intend to use mobility hubs when the walking time to the mobility hub is less than 10 minutes	Schikofsky et al. (2020), Geurs and Münzel (2022)
Behavioral intention	I intend to use mobility hubs more often when additional facilities are available such as a parcel locker	By author
Performance expectancy	I expect to save time when travelling using a mobility hub compared to my current way of travelling	Van 't Veer (2021), modified
Performance expectancy	I expect that travel options offered at a mobility hub will make it more convenient to reach my destination	Van 't Veer (2021), modified
Performance expectancy	It will be convenient that a mobility hub will have various means of transportation on a single location	Back (2021), modified
Effort expectancy	I expect that using a mobility hub would be easy for me	Jain et al. (2021), modified
Effort expectancy	I expect that making reservations would be easy for me	Jain et al. (2021), modified
Effort expectancy	I don't need a private car if shared cars are available everywhere and any time	By author
Social influence	I am willing to use mobility hubs if people who are important to me think that I should use it	Ye et al. (2020), modified

Social influence	I'd rather wait for other people to try out mobility hubs before I will use them	By author
Social influence	Using mobility hubs would give other people a good impression of me	Jain et al. (2021), modified
Social influence	I am willing to use mobility hubs if the media covers it positively	Ye et al. (2020), modified
Facilitating conditions	I am familiar with the operation of my smartphone and carry it with me when I am out	Ye et al. (2020)
Facilitating conditions	I have a stable mobile network when I am travelling	Ye et al. (2020)
Facilitating conditions	I am used to do payments on my smartphone	Ye et al. (2020), modified
Hedonic motivation	I think that using a mobility hub would be fun and enjoyable	Schikofsky et al. (2020), modified
Hedonic motivation	I think it's very interesting to try out transport modes offered by hubs	Van 't Veer (2021), modified
Hedonic motivation	I would enjoy trying out different electric powered vehicles from mobility hubs	By author
Price value	I expect to save money when using mobility hubs, compared to my current way of travelling	Van 't Veer (2021), modified
Price value	I would be willing to pay more for shared transport from a mobility hub than I currently spend on mobility	By author
Environmental concern	I am very concerned about the environment	By author
Environmental concern	I am willing to reduce my CO2 emissions to protect the environment	Kilbourne and Pickett (2008), modified
Environmental concern	I think mobility hubs will help reduce CO2 emissions	Back (2021), modified
Environmental concern	I expect to make use of mobility hubs in order to travel more environmentally friendly	Back (2021), modified
Individual innovation	I am curious to try new things	Ye et al. (2020)
Individual innovation	I like to experiment with new services such as mobility hubs	Back (2021), modified
Individual innovation	I usually take the lead in trying new technologies, such as mobility hubs, compared to people around me	Ye et al. (2020), modified

5 Results

In this section the results and outcomes of the survey are shown. First, the sample's socio-demographics are reviewed, after which the general findings are discussed. Then a factor analysis is done to find corresponding factors influencing the intention to use mobility offered by mobility hubs. Lastly, a latent class cluster analysis is executed and the specific clusters are analysed using the moderators discussed in section 3.4.

The survey was distributed between May 16 and May 30 2022. In total 314 respondents filled in the survey, from which 298 completed it (response rate = 95%). Respondents that did not fully complete the survey were deleted from the sample. The number of respondents thus fulfilled the minimal sample needed to perform an Exploratory Factor Analysis (Field, 2009; Kass & Tinsley, 1979). Every respondent fulfilled the minimum age of 18, which was needed in order to complete the survey. The average time to complete the survey was 17 minutes, with a median of 9 minutes. This however includes the persons who left the survey open without completing the survey directly. This resulted in a maximum time of 654 minutes. When only the times within 60 minutes are considered, an average of 10 minutes was needed to complete the survey.

5.1 Descriptive results

The sample's socio-demographics are compared with the Dutch population in order to determine whether the sample is representative for the total population. The population data is retrieved from CBS Statline. The comparison of the sample and the Dutch population can be seen in Table 13.

Table 13: Socio-demographical statistics

		Percentage in sample	**Percentage in population**
			CBS Statline (2021c)
Gender	Female	38.3%	50.3%
	Male	61.1%	49.7%
	I'd rather not tell	0.7%	-
			CBS Statline (2021b)
Age	18-25	31.9%	10.1%
	26-35	30.9%	12.9%
	36-45	11.1%	11.9%
	46-55	11.4%	14,1%
	59-64	11.1%	13.5%
	65+	3.7%	19.4%
			CBS Statline (2020a)
Household gross yearly income	Less than €20.000	15.8%	23.3%
	€20,000 until €30,000	6.0%	30.7%
	€30,000 until €40,000	16.1%	24.0%
	€40,000 until €50,000	11.7%	12.2%
	€50,000 until €100,000	30.5%	8.7%
	€100,000 or more	7.4%	1.0%
	I'd rather not say	12.4%	-
			CBS Statline (2021e)
Household composition	Single	15.4%	17.7%
	Living together, without children	37.2%	49.3%
	Living together, with children	22.1%	26.5%
	Single with children	1.0%	3.4%
	With roommates / students house	19.8%	-
	Other	4.4%	3.0%
			CBS Statline (2021a)
Work situation	I work full time	52.3%	36.5%
	I work part time	20.8%	33.9%
	I am unemployed, looking for a job or unfit for work	2.3%	
	I am retired	3.0%	
	I am a student	21.5%	29.6%
			CBS Statline (2020b)
Degree of urbanity	Very strongly urban (>2500)	44.3%	10,5%
	Strongly urban (1500 - 2500)	20.8%	15.2%
	Moderately urban (1000-1500)	8.1%	11.2%
	Little urban (500-1000)	12.4%	13.5%
	Non-urban (<500)	4.4%	49.6%
	No postal code given	10.1%	-

Regarding gender, men are overrepresented in the sample, compared to the Dutch population. This can be explained by the fact that men are more often found to be users of shared transport (Liao & Correia, 2019). Besides, men are more likely to be early adopters of new technologies (El Zarwi et al., 2017). Because of these interests, men possibly had a greater need to fill in the survey. The sample contains many young people of 18 - 35 years old (62.8% of sample), and relatively few older people of 65+ (3.7% of sample). This is not representative with the Dutch sample, however it is expected when taken into account the target group of innovations, shared mobility in particular. Young people prevail the group of early adopters (see section 3.4), which are more disposed to make use of innovations. This however must be taken into account when interpreting the results and might lead to an overestimation of the intention to use mobility offered at a mobility hub.

Household composition is mostly comparable with the Dutch population. In the sample, persons living together without children are slightly lower than in the population. Since CBS Statline doesn't include roommates or students in its statistics, this field is empty and the statistics are not fully comparable with each other.

Regarding the working situation, the sample consists of more people working fulltime (52.3%) than in the Dutch population (36.5%). As can be seen, the last three items (unemployed, looking for a job or unfit for work; retired; student) are grouped in the Dutch statistics. CBS Statline includes information about the 'non-working' population, consisting of people who have not recently looked for paid work and who are not immediately available to work (CBS Statline, 2021a). This concerns students, disabled persons and people which are retired. In order to compare the statistics with the research sample, the job seekers are added in the population percentage.

In the questionnaire, the respondents were asked to give their first four digits of their postal code. As can be seen in Figure 23, most of the respondents live in the Randstad area. Respondents mainly live in the provinces of Zuid Holland and Utrecht. In order to compare these results with CBS Statline, the respondents' municipality have been modified into the degree of urbanity. The classification of municipalities according to urbanity is based on the local address density of the municipality (CBS Statline, 2020b). This results in five urbanization classes based on class boundaries of 2,500, 1,500, 1,000 and 500 addresses per km^2. The degree of urbanization does not correspond well with the Dutch sample: from the sample population, the majority lives in urban environments. The survey is distributed among places in the Netherlands, in neighborhoods where a hub could possibly be placed. From the literature study (section 3.1.1), it became clear that neighborhood mobility hubs often are situated in urban residential areas or rural zones. The literature study among potential hub users and users of shared transport stated that most hub users live in urban environments. This is supported by this study. In Table 23 (Appendix F), the degree of urbanity has been compared with the respondents' intention to use mobility hubs. The results show that people living in very strongly urban or strongly urban environments have an higher intention to use hubs than people living in lower density areas. The Chi-square value is < 0.05, which means that the sample is unrepresentative of the population.

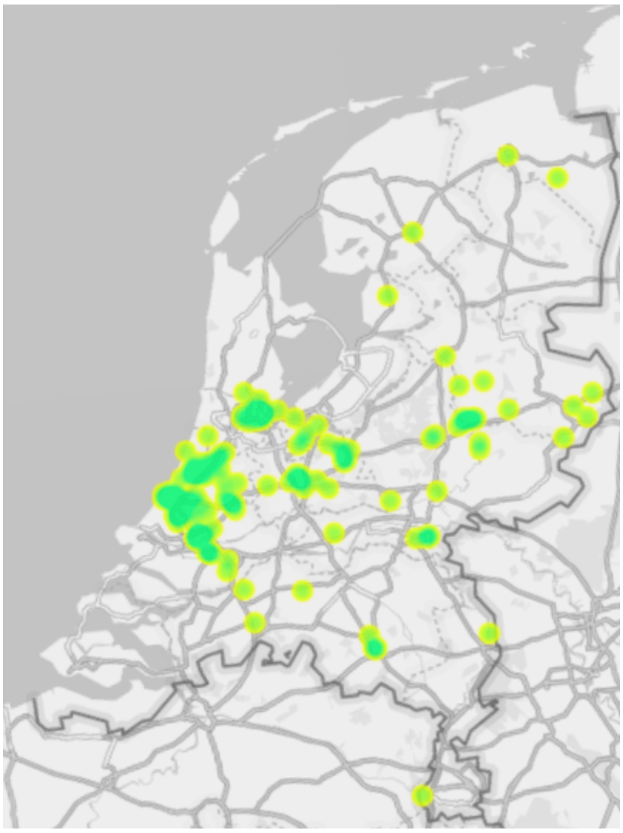


Figure 23: Visualization of respondents' residential area

The level of education cannot be fully compared with the Dutch population, due to a difference in education levels. In Table 14, the educational statistics are shown. Highly educated people are overrepresented in the sample: more than 80% of the sample are categorized as highly educated (having an HBO degree or higher). According to PBL (2008), higher educational levels have a positive association with car ownership. However, the sample data on the number of cars per household does not suggest this: the percentage of people having no car is higher in this sample than in the Dutch population.

The Dutch statistics of having a drivers licence is slightly adjusted, so that it only considers people older than 18 years old (In the Netherlands it is possible to get a drivers license at age 17). This is done so that the sample is comparable with the research sample, where only persons older than 18 years old could participate. The results show that a high share of persons (96.0%) who participated in the survey has a driver's license. This is an interesting result, when compared with the share of cars per household which is shown to be lower than the Dutch population. More people in the sample are thus able to drive a car, however less households own a car.

Table 14: Socio-demographical statistics education

		Percentage in sample		Percentage in population
				CBS Statline (2021d)
Educational level	Primary- or secondary education	6.7%	Primary education//VMBO/MBO	54.8%
	MBO, or similar	13.1%	HAVO/VWO	9.4%
	HBO / WO Bachelor or similar	44.6%	HBO, WO bachelor	21.5%
	Master's Degree	35.6%	HBO, WO master, docterate	12.7%
			Unknown	1.7%

Table 15: Socio-demographical statistics

		Percentage in sample	Percentage in population
			CBS Statline (2021f)
Drivers licence	Yes	96.0%	80.8%
	No	4.0%	19.2%
			KiM (2021b)
Cars in household	No car	33.6%	26.0%
	One car	38.9%	47.0%
	Two cars or more	27.5%	27.0%

Overall, it can be concluded that the sample is not fully representative with the Dutch population. This may be caused by the way how the survey was distributed and how the respondents were approached in the different cities. According to literature, the target group of shared mobility users are mainly young, highly educated persons living in urban environments (see section 3.1.5). This could be another reason why the sample is not fully representative with the Dutch population. Since this group is overrepresented in the sample, it is likely that there is an overestimation of the intention to use mobility offered at a neighborhood mobility hub. In the next section, further analysis will be done into the current travel behavior and the intention to use mobility hubs.

5.2 General findings

In this section, the general findings of this research are presented, before the factor analysis and latent class cluster analysis are executed. This section begins with explaining the current travel behavior of the respondents. Secondly, an overview is given of the statements regarding the intention to use mobility hubs. These first two aspects are used to answer sub question 3: *what is the relation between users' current mobility pattern and their intention to use mobility hubs*? Furthermore an overview is shown of the preferred modes of shared transport offered by a mobility hub and lastly an indication is given about the effect of a mobility hub on car usage and car ownership.

Current travel pattern

In order to see whether there exists a relationship between the current travel behavior of users and its potential hub usage, a closer look is needed at both aspects. In Figure 24, the current travel behavior of the research sample is given, specified per trip purpose. Regarding a visit to *friends and/or family*, the car and (electric) bicycle are popular. The frequency of a trip however is different. The persons that cycle visit their *friends and/or family* more often than those who take the car (Appendix F;Table 24). A trip towards a *sports and/or hobby* activity is often done using the (electric) bicycle (61.4%). When going to the supermarket is mostly done using walking, followed by the bicycle and car. The travel behavior regarding a trip to *work and/or study* is distributed more evenly among the (e-)bike (26.8%), train (33.2%) and car (31.2%). Not surprisingly, the frequency of those trips is high: 1 to 3 days a week or 4 days or more a week (Appendix F;Table 25). It is noticeable that the number of people who travel to work and/or study by train and bicycle is high, compared to the situation in the Netherlands. Data from CBS Statline (2020c) show that travel behavior to work is mainly by car (63.7%), with 13.9% traveling by train and only 6.7% by bicycle.

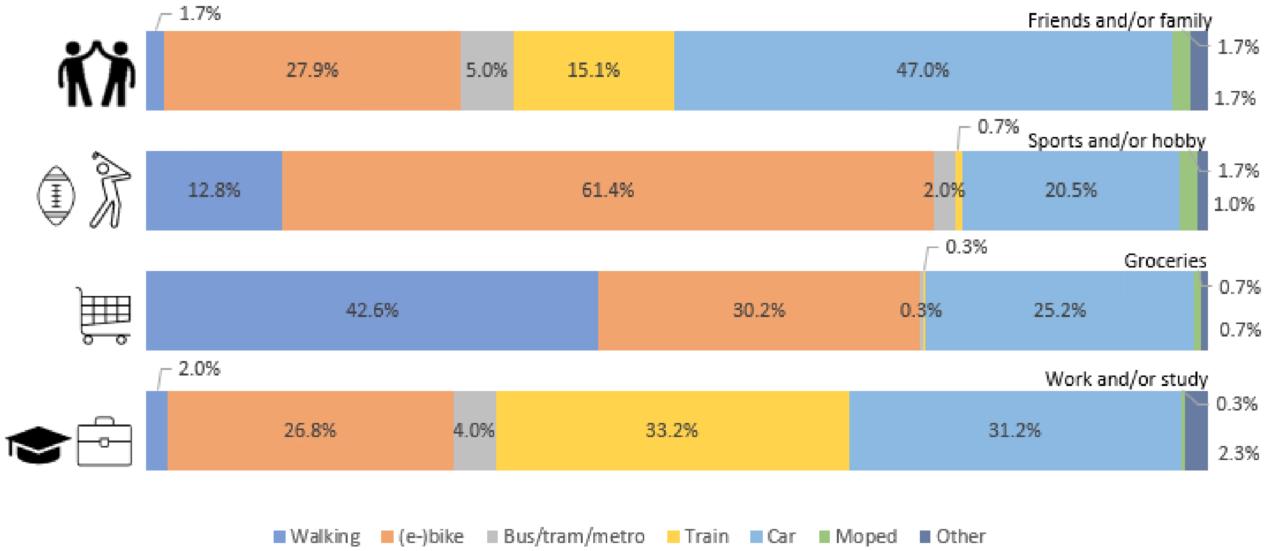


Figure 24: Samples' current travel behavior per travel purpose

Intention to use mobility hubs

In total, five statements were asked to the respondents in order to get an indication of their intention to use neighborhood mobility hubs. Since the intention to use mobility hubs will be included as a factor in the LCCA, a reliability analysis using Cronbach's Alpha was done in order to see whether the set of items are closely related as a group. It turned out that $BI4$ ("I intend to use mobility hubs when the walking distance is less than 10 minutes") and $BI5$ ("I intent to use mobility hubs more often when additional facilities are available, such as parcel lockers") resulted in a lower Cronbach's Alpha. These statements were deleted from the construct, resulting in a reliable set of items ($\alpha = 0.88$). In order to determine whether the other three items of behavioral intention are statistically different, Friedman's Anova test is used. Friedman's test is used to test for differences between dependent groups and is advised to use when ordinal questions are asked, which is the case. The null hypothesis suggests that there are no differences between the variables ($p > 0.05$). The items BI1, BI2 and BI3 show a statistically significant difference between the intention to use neighborhood mobility hubs (X2(2) =113.818, $p < 0.001$). Furthermore, a Wilcoxon test was executed as a post hoc test to establish within-subjects differences. The Wilcoxon test also showed a significant difference ($p < 0.001$) between all three items. The intention to use hubs is for example higher ($p < 0.001$) when a walking time of 5 minutes is mentioned (sum = 107), than when no walking time is mentioned (BI2; sum = 26). The full analysis, as well as the two excluded statements can be depicted in Appendix F (Table 26, Table 27, Figure 31).

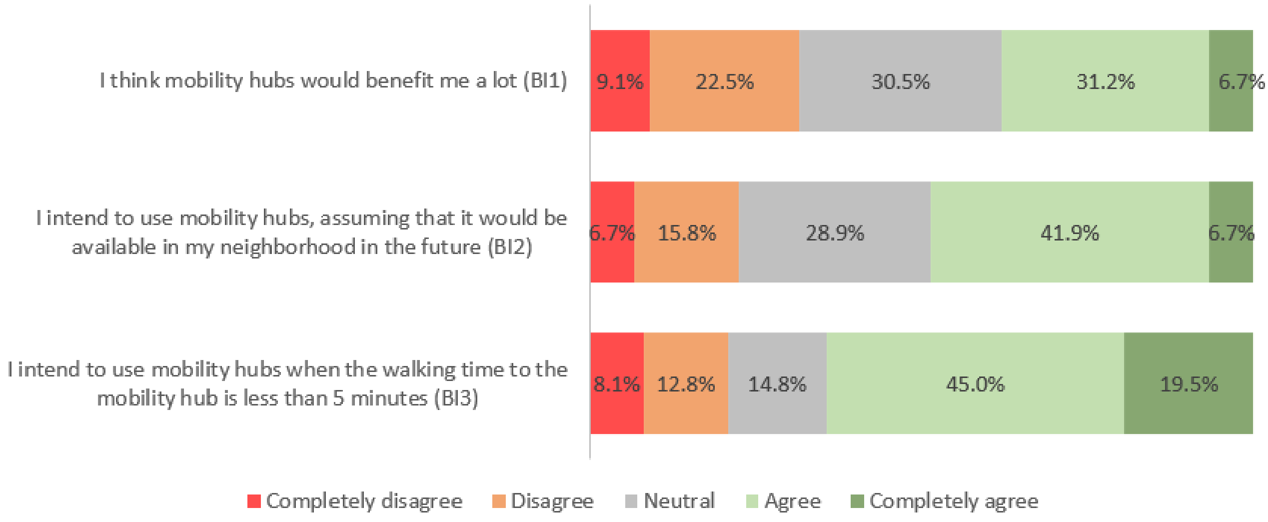


Figure 25: Intention to use neighborhood mobility hubs

The responses on the three statements about intention to use neighborhood mobility hubs can be seen in Figure 25. For the first two statements, the majority of the sample indicates to disagree or be neutral to the statements. 37.9% of the sample indicates that a mobility hub would benefit them a lot. 48.6% of the sample assumes that they would intend to use a mobility hub when it would be available in their neighborhood. The third statement is striking: when a time element of 5 minutes walking is added, the intention to use mobility hubs has increased. When having a mobility within 5 minutes of walking, 64.5% of the sample indicates that they would intent to use mobility offered at a hub. These statements reveal that the sample has a fairly positive attitude towards intending to use mobility hubs.

These figures show a more positive image about the intention to use mobility hubs than the research discussed in the literature section, as can be expected looking at the sample characteristics. Moreover, it may be due to the fact that these questions do not yet carry a specific weight. There is no urgency in the questions yet, e.g. it is not yet asked whether the respondents would use their car less or get rid of it. The latter is expected to yield a less positive result. More on this later in this section.

Relation between current travel behavior and intention to use mobility hubs

Since shared mobility offered at a mobility hub would require a behavioral shift towards a more multi-modal way of travelling, it is expected that people who have experience with such multi-model services have a greater tendency to change their travel behavior in that direction (see section 3.1.5). Moreover, it is expected that travelers which already have a green and sustainable mindset would have higher intentions to use shared mobility. Below an overview is given of respondents' current travel behavior towards *work and/or study* (Figure 26) and its relation with their intention to use mobility hubs in the future. The relation between *sports and/or hobby* and *friends and/or family* and the intention to use hubs are showed in Appendix F (Figure 32, Figure 33). The travel behavior towards doing groceries is left out of this analysis, since it provides no added value for this research. Regarding the intention to use mobility hubs it is decided to use the question "I intend to use mobility hubs, assuming that it would be available in my neighborhood in the future", since it is the most complete behavioral intention related question. In the LCCA an aggregated score for behavioral intention will be used, however using that score for this analysis makes interpretation more difficult.

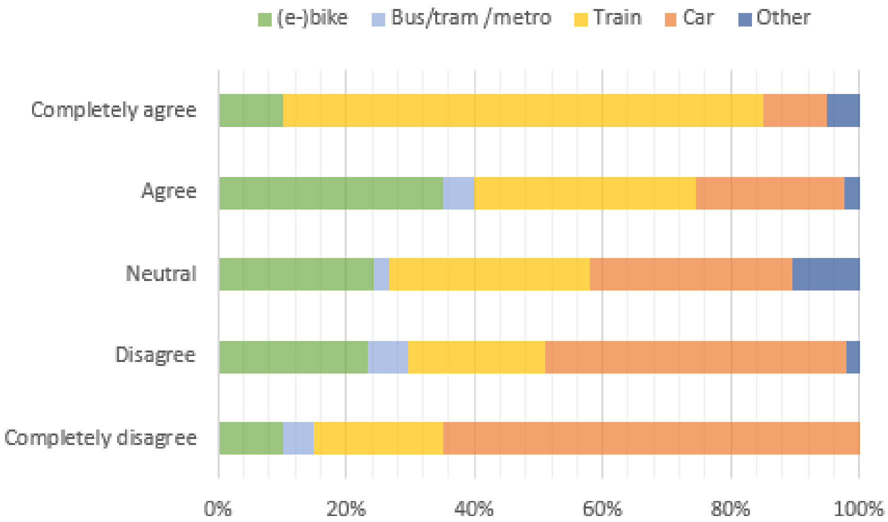


Figure 26: Current travel behavior to travel to work and/or study and its relationship with intention to use mobility hubs

As can be seen in Figure 26, a large share of people that (completely) disagree with the question, use their car to go to *work and/or study*, indicating that they have less intention to use neighborhood mobility hubs in the future. Moreover, it can be seen that the proportion of car drivers is decreasing more and more, as a more positive image is formed about the intention to use mobility hubs. People that completely agree with the statement are mostly train travelers, which was expected. Besides, people using their (e-)bike to travel to *work and/or study* also have a higher intention to make use of mobility hubs in the future. The low impact of bus, tram and metro is likely to be caused to the low share of respondents traveling with those modes. From the figure it can be concluded that particular the travelers that choose a green and sustainable travel mode, have higher intentions of making use of shared mobility offered at mobility hubs.

About the same pattern can be seen when looking at the relation between *sports and/or hobby* and *friends and/or family* and the intention to use neighborhood mobility hubs (Appendix F; Figure 32, Figure 33). The share of car drivers is high when the respondent (completely) disagree with the statement. When being more positive about the intention to use hubs (agree and completely agree with the statement), the share of car drivers decreases drastically. Regarding *sports and/or hobby*, most people currently use the (e-)bike to reach their travel purpose and have high intentions to use neighborhood mobility in the future. For the travel purpose *friends and/or family*, it is more difficult to give an indication since a more diverse travel pattern can be seen. In this, (e-)bike, train and car travelers are potentially intending to use mobility hubs in the future.

Overall, it can be concluded that from the survey outcomes that particular the travelers that already choose a green and sustainable travel mode ((e-)bike, train), have higher intentions of making use of shared mobility offered at mobility hubs. In the LCCA (executed in section subsection 5.4), the relationship between each cluster's current travel behavior and their point of view regarding mobility hubs will also be considered.

Modes of transport offered at the mobility hub

It is interesting to investigate which type of shared mobility from a mobility hub is preferred. The respondents were asked whether they would consider using specific modes of transport offered by the hub, if one would be present at their neighborhood. The results can be seen in Figure 27. From the table we can infer that the shared car is the most preferred mode of transport. The shared bicycle is found to be the least favourite mode of transport: 68.1% of the respondents indicate that they would never make use of a shared bicycle when its offered at a neighborhood mobility hub. A reason for this may be the presence of a bicycle at home, which makes using one from the hub unlikely. The shared moped is intended to be used quite often: 16.1% of the sample expects to use it every month. The shared cargo bike is not expected to be used very often, however 28.5% of the respondents expects to make use of it a few times a year.

In Appendix F, the modes of transport are specified per age group (Figure 34, Figure 35, Figure 36). What can be seen here is that the shared car is popular mode of travel among all age groups. The intention to use a shared moped mainly applies to the age group 18 - 25 years old and to a lesser extend on the age groups between 26 and 45 years old. An e-bike is a more popular mode of travel when being older than 36 years old, especially when the usage is a few times a year. For people in the age of 65+, the e-bike is the second most used mode of travel which the respondents intend to make use of. The shared cargo bike is mainly popular in the age of 26-45 years old. This probably has to do with the presence of young children in the household.

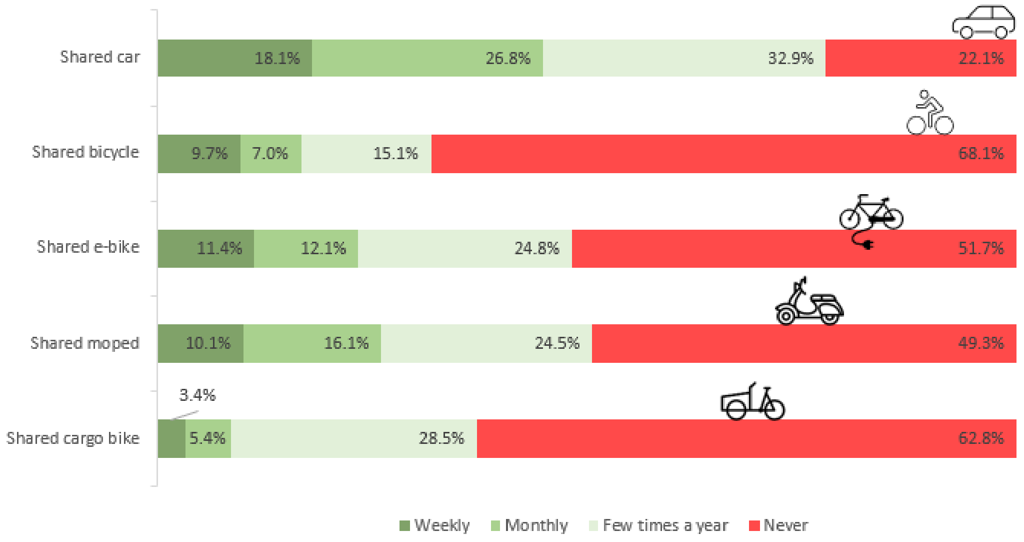


Figure 27: Intention to use specific modes of transport

Furthermore, the modes of transport are specified per degree of urbanity (Appendix F; Figure 37, Figure 38, Figure 39). In general, the intention to use shared transport is lower when people live little urban or non-urban. It is striking, however, that the shared e-bike is popular for monthly use in non-urban areas. The opposite can be seen for the shared scooter, which is especially popular in very strongly urban areas. When we look at the difference in intention between men and women (Figure 40, Figure 41, Figure 42), it is noticeable that women have a higher intention to use hubs, for each mode of transport. For the shared car and shared mopeds there is a minimal difference in potential usage, however when looking at the shared (e-)bike and shared cargo bike, the women are clearly in favor of using those modes.

Effects on car usage and car ownership
This study explicitly refers to the high degree of car ownership in the Netherlands, which could potentially be decreased using mobility hubs. Using the LCCA, one of the sub questions related to car ownership per cluster will be answered. In Figure 28, a first overview is given of the respondents' expectations on car usage and car ownership when a mobility hub would be present in their neighborhood. The statements do not add up to 100%, since the 6th answering option ("not applicable to me") is left out of figure to keep it well-arranged. The answering option "not applicable to me" is related to the respondents who never make use of a car, do not own a car and/or do not own a second or third car. Of the whole sample, 21.4% (64 respondents) expects that the presence of a mobility hub would result in less usage of their car. 14.8% of the respondents (44 respondents) would expect to give up their second or third owned car, when a mobility hub would be present in their neighborhood. 8% of the sample (24 respondents) indicate that they would consider selling the only owned car. These findings corresponds largely with findings of the studies from Claasen (2020) and Van Rooij (2020), who also studied the effects of a mobility hub on car ownership.

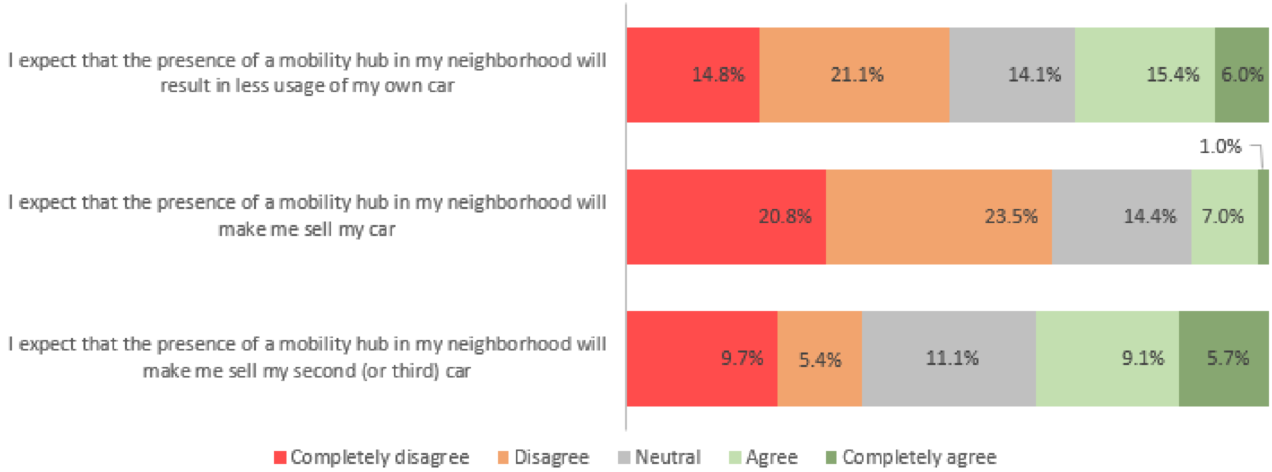


Figure 28: Effects of mobility hub on car usage and car ownership

Sub-question 3: What is the relation between users' current mobility pattern and the intention to use neighborhood mobility hubs?

In answering this research question, the current travel behavior to *work and/or study*, to *sports and/or hobby* and to *friends and/or family* was examined. For all three travel purposes, about the same trend can be seen. The majority of the people which have a low intention to use neighborhood mobility hubs, currently often use their car to reach their destination. When being more positive about the intention to use, the share of car drivers decreases. The majority of the people which intent to use neighborhood mobility hubs in the future currently travel to work and/or study by train and (e-)bike. Towards sports and/or hobbies, people that currently often take the (e-)bike have higher intentions of using a mobility hub. Moreover, it was examined that travelers which intend to use neighborhood hubs in the future currently travel towards family and/or friends with the (e-)bike, the train or the car.

Overall, it can be concluded from the survey outcomes that people with a higher intention to use neighborhood mobility hubs show a larger share of people traveling by train or by (e-)bike. On the other side, people with a low(er) intention to use hubs have a larger percentage of people traveling by car to their work and/or study.

5.3 Exploratory Factor Analysis

The Exploratory Factor Analysis is executed using IBM SPSS Statistics (version 28) by performing the steps described in the methodology (section 2.3). The EFA was run using the Principal Axis Factoring and Direct Oblimin rotation technique. The minimum factor loading criteria for 300 respondents is 0.298 (section 2.3; Table 3), so the minimal value in SPSS is set to 0.30.
The first iteration gave a Kaiser-Meyer-Olkin (KMO) value of 0.885 and a significant Bartlett's Test of Sphericity ($p = 0.000$). This means that the sample is 'meritious' and that the data is suitable for factor analysis. All communalities had a value higher than 0.20. Using the Kaiser rule and a scree plot the number of factors could be determined. The factor solution derived from the first iteration consists of 6 factors, which accounted for 64.06 percent of the variation in the data. Nonetheless, the determinant of the correlation matrix, a number of factor loadings, cross-loadings and the number of items per factor did not adhere to the set thresholds.

Consequently, factors were removed that had less than three items with a factor loading higher than 0.40. Variables were removed having too low factor loading or too high cross-loadings. This eventually resulted in a four-dimensional structure, having a KMO of 0.874. The 4 factors explained a total of 60.227 percent of the variance among the items in the study. The Bartlett's Test of Sphericity proved to be significant ($p=0.000$) and all communalities were larger than the required value of 0.20. The determinant of the correlation matrix was <0.001 and is higher than the required value of 0.00001. In Table 16, the results of the factor analysis can be seen.

As one of the last steps, the values of the Cronbach's Alpha needed to be calculated (Table 17). A Cronbach's Alpha higher than 0.60 is acceptable for exploratory research (Straub & Gefen, 2004). All factors adhere to this criteria and have sufficiently high score, meaning that the items are closely related within that factor and it can be said that the factor is able to demonstrate 'acceptable reliability' (Straub & Gefen, 2004).

Table 16: Results Exploratory Factor Analysis

Items	1	2	3	4
Mobility hub beneficials				
PE1	0.540			
PE2	0.702			
PE3	0.515			
EE1	0.839			
EE2	0.628			
HM1	0.486			
HM2	0.481			
Facilitating conditions				
FC1		0.829		
FC2		0.781		
FC3		0.626		
Individual innovation scepticism				
II1			-0.752	
II2			-0.799	
II3			-0.702	
Social-Environmental responsibility				
SI1				0.634
SI3				0.752
SI4				0.705
EC1				0.508
EC2				0.519
EC3				0.468
EC4				0.635

Table 17: Cronbach's Alpha per factor

Factor	**Cronbach's Alpha**
Mobility hub beneficials	0.852
Facilitating conditions	0.744
Individual Innovation scepticism	0.823
Social-Environmental responsibility	0.725

In Table 16, the four factors can be seen. In comparison with the conceptual model (Figure 21), only price value (PV) did not withstood the factor analysis. PV1 had a too low communality when having a four factor model, PV2 was deleted from the factor because of too high factor cross-loadings. The constructs performance expectancy, effort expectancy and hedonic motivation together belong to the first factor: mobility hub beneficials. The reason that these three constructs belong to one factor may have to do with the fact that all these questions are related with the advantages of mobility hubs. Not all variables survived the factor analysis. both EE3 and HM3 had too high cross-loadings and thus had to be deleted from the model.

The items belonging to factor 2 and 3 are the same as in the conceptual model. The items of factor 3 however have negative factor loadings, indicating that people which score high on this construct, have a lower degree of individual innovation. The name of the factor is therefor adjusted to individual innovation scepticism.

The constructs social influence and environmental concern combined form the last factor: social-environmental responsibility. This combination of constructs is a bit surprising, but the model clearly uncovers similarities between an individuals social influence and their concern about the environment. SI2 is not part of this factor since its communality was too low (0.136) when decreasing the number of factors. According to the factor analysis, people thus concern themselves about the environment, sees a role of a mobility hub to contribute to carbon dioxide emissions and at the same time care about social influence of (important) others. This also applies in the opposite direction: according to the sample population, the people that care less about the environment also think that the opinion of others is less important to them.

To conclude, after executing a Exploratory Factor analysis, four factors are made up by the sample data: (1) mobility hub beneficials, (2) facilitating conditions, (3) individual innovation scepticism and (4) social-environmental responsibility. These factors will serve as input for the latent class cluster model, described in next section.

5.4 Latent Class Cluster Analysis

A latent class cluster analysis is executed in order to find homogeneous groups in the sample that are similar based on observed characteristics and regarding to their intention to use mobility offered by neighborhood mobility hubs. First of all, the factor scores of previous section were calculated, by summing up the items belonging to each of the four factors, and dividing them by the number of items per factor. An extra factor is added to the model regarding the intention to use mobility hubs. The factor has been added to make it easier to interpret each of the classes of the LCCA.

The LCCA is executed using LatentGOLD (version 5.1). The factor scores are used as input for the LCCA. By following the steps from section 2.4, first the model fit needs to be determined using the likelihood-ratio chi-squared statistic. Since items for the factor scores are summed and averaged, the resulting factor score is a continuous variable. When having indicators with a continuous scale, LatentGOLD is not able to determine the chi square value (Magidson & Vermunt, 2016). This step could thus not be executed.

To determine the most parsimonious model, first the measurement model (so without adding covariates) needs to be estimated. The guideline here is to choose the number of clusters with the lowest value of BIC(LL) and AIC(LL) (Magidson & Vermunt, 2016). In Table 18 the BIC(LL) and AIC(LL) of the first 10 clusters can be found. The lowest value of BIC(LL) and AIC(LL) can be found at the 10th cluster, which is not desirable. One of the goals of a LCCA is to find the model with the smallest number of latent classes (Molin et al., 2016), which is not the case when having 10 clusters. A solution for this is to calculate the percentual change of BIC(LL) between clusters, in order to determine the optimal number of classes (Alonso-González et al., 2020; Van 't Veer, 2021). When the percentual change in the BIC-value shows only a small improvement in model fit, the optimal number of clusters is reached.

Table 18: Number of clusters and its model fit statistics

#-Cluster	LL	BIC(LL)	AIC(LL)	Npar	Class.Err.	% change BIC(LL)
1-Cluster	-1756.80	3570.57	3533.60	10	0.0000	-
2-Cluster	-1538.70	3197.04	3119.40	21	0.0416	-10.46%
3-Cluster	-1248.36	2679.02	2560.72	32	0.0262	-16.20%
4-Cluster	-1170.72	2586.41	2427.43	43	0.0400	-3.46%
5-Cluster	-1118.94	2545.53	2345.89	54	0.0514	-1.58%
6-Cluster	-1085.23	2540.77	2300.46	65	0.0790	-0.19%
7-Cluster	-1035.52	2504.01	2223.03	76	0.0489	-1.45%
8-Cluster	-996.53	2488.72	2167.07	87	0.0537	-0.61%
9-Cluster	-970.82	2499.96	2137.64	98	0.0582	0.45%
10-Cluster	-914.23	2449.45	2046.47	109	0.0436	-2.02%

From on cluster 4, little improvements can be seen in percentual change of the BIC(LL) value. Consequently, for the 4,5 and 6 cluster model, the Bivariate Residual values have been examined. A BVR value < 3.84 is preferred, indicating that the clusters are significantly independent of each other. Only the 6-cluster model was found to have most of the BVR values < 3.84, however the 5th and 6th cluster had a small size ($< 7\%$). As a result, the clusters are represented by very few members and interpretation is difficult. In turn, the 5-cluster model experienced a high level of covariance (BVR > 3.84) between the indicators behavioral intention and mobility hub beneficials. This was solved by including a direct effect between these indicators, which relaxes the assumption of local independence (Magidson & Vermunt, 2005). The interpretation of the 5-cluster model however is limited, since cluster 1 and 2 and cluster 3 and 5 had many similarities and could not be distinguished from each other. At last, the 4-cluster model turned out to form a parsimonious model that could account for the associations between the variables. The 4-cluster model also showed a high level of covariance between mobility hub beneficials and behavioral intention and individual innovation scepticism and social-environmental responsibility. Direct effects were applied between those indicators and the BVR results are shown in Table 19. As can be seen, only the BVR value between social-environmental responsibility and mobility hub beneficials is just non-significant.

Table 19: BVR values of LCCA indicators

Indicators	Mobility hub beneficials	Facilitating conditions	Individual innovation scepticism	Social-environmental responsibility	Behavioral intention
Mobility hub beneficials	.				
Facilitating conditions	0.1735	.			
Individual innovation scepticism	0.3763	0.8239	.		
Social-environmental responsibility	**4.1942**	0.6265	0.0000	.	
Behavioral intention	0.0000	1.7518	2.0274	1.4931	.

After analyzing the percentual change in BIC values, the BVR values and its corresponding clusters, the 4-cluster model is found to be the most suitable for further analysis and interpretation. The next step is to add all the covariates (the moderators of the conceptual model) to the model as active covariates and remove the ones which are non-significant (Wald < 3.84 and $p > 0.05$). Using backwards elimination, the insignificant covariates were removed from the model, but are still present as inactive covariates. In this way, they no longer have an effect on the class-membership but can still be used for interpretation. As a last step the Entropy R-squared is determined, to check how accurately the model defines the classes, based on the observed variables. In other words, an estimate of the probability is given that each of the individuals is present in the different clusters. The Entropy R-squared is 0.9412, indicating that the model indicate a good classification of all individual cases into the four clusters. In Figure 29, the average factor scores of the indicators, specified per cluster, can be seen. The combination of the active covariates, together with the indicators, result in the final model which can be seen in Table 20. The inactive covariates have been included in the table. For the covariates, the rightmost column has been added which shows the share of each socio-demographic within the sample population. The difference from the average (sample population) can be seen very clearly in this manner. The latter three variables regarding the effects of a mobility hub on car usage and car ownership were not included as a moderator in the conceptual model, but are included in the final LCCA table because of its relevance to this study. Moreover, it has been chosen to add a covariate 'work situation' to the model, so that a distinction could be made between students and people having a full- or part-time job. Lastly, the moderator hub functionalities is not included as a covariate, given the variety of answers to this statement and low reliability score. In Figure 30 a visualisation of the clusters can be seen, together with its dominant covariates.

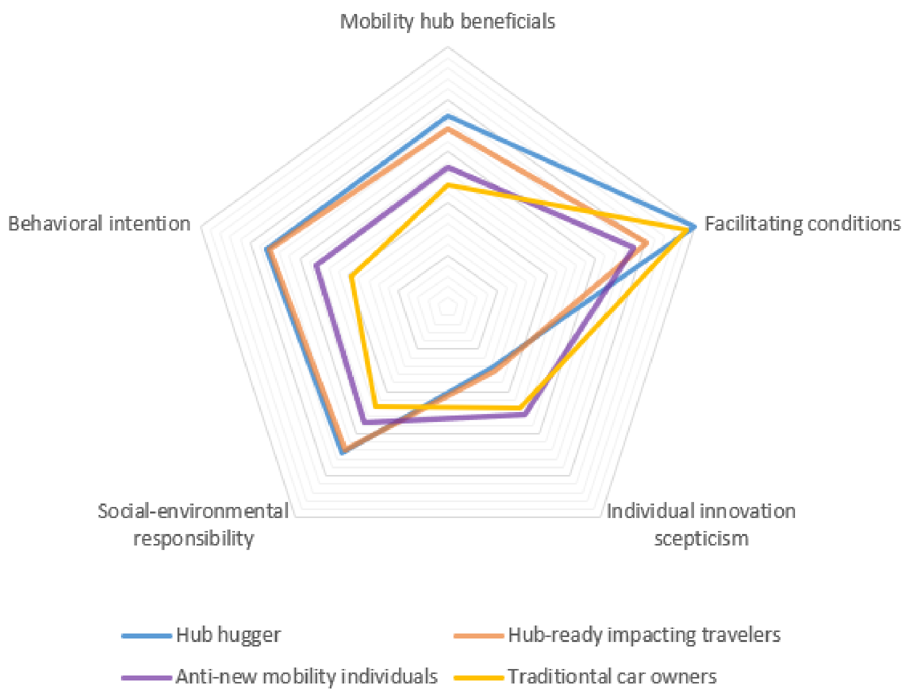


Figure 29: Average score of the five EFA factors for the different clusters

Cluster 1: Hub Hugger
The first cluster is directly the largest cluster of all, presenting 45 % of the sample. The cluster is named *hub hugger* since members of the cluster experience the highest level of behavioral intention to use neighborhood mobility hubs. Besides, they perceive a high value of mobility hub beneficials, meaning that the members believe that mobility hubs can improve their performance, are free from effort and are fun to use. The value of individual innovation scepticism is low, which shows that the individuals are open for new technologies. Moreover, the cluster members are socially and environmentally responsible: they listen to other people and care about the environment. The cluster consists of relatively young people, 85% of the cluster has a age of 35 or younger and most of the individuals are highly educated. Most *hub huggers* have a job (fulltime or parttime) or still studying (32%). 47% of the cluster does not own a car and the individuals mainly travel to their work or study using the train or (e-)bike. These sustainable means of transport fit into the picture of a social-environmental mentality. Besides, these modes of transport are popular in cities, what is confirmed by the level of urbanity, which is very strongly urban for 57% of the members. Prior experience with shared transport is likely to influence the intention to use mobility hubs: the majority (82%) of the cluster have used shared transport in the past, which is the highest percentage on this item of all clusters. 25% of the *hub huggers* indicate that they would use their car less often when a hub is present in their neighborhood. When a hub is stationed in their neighborhood, 17% of members will sell their second owned car, and 9% will sell their only owned car. These latter percentages are not the highest of all clusters. This is probably due to the high share of students in this cluster of which the majority do not own a car (see share of 'not applicable to me').

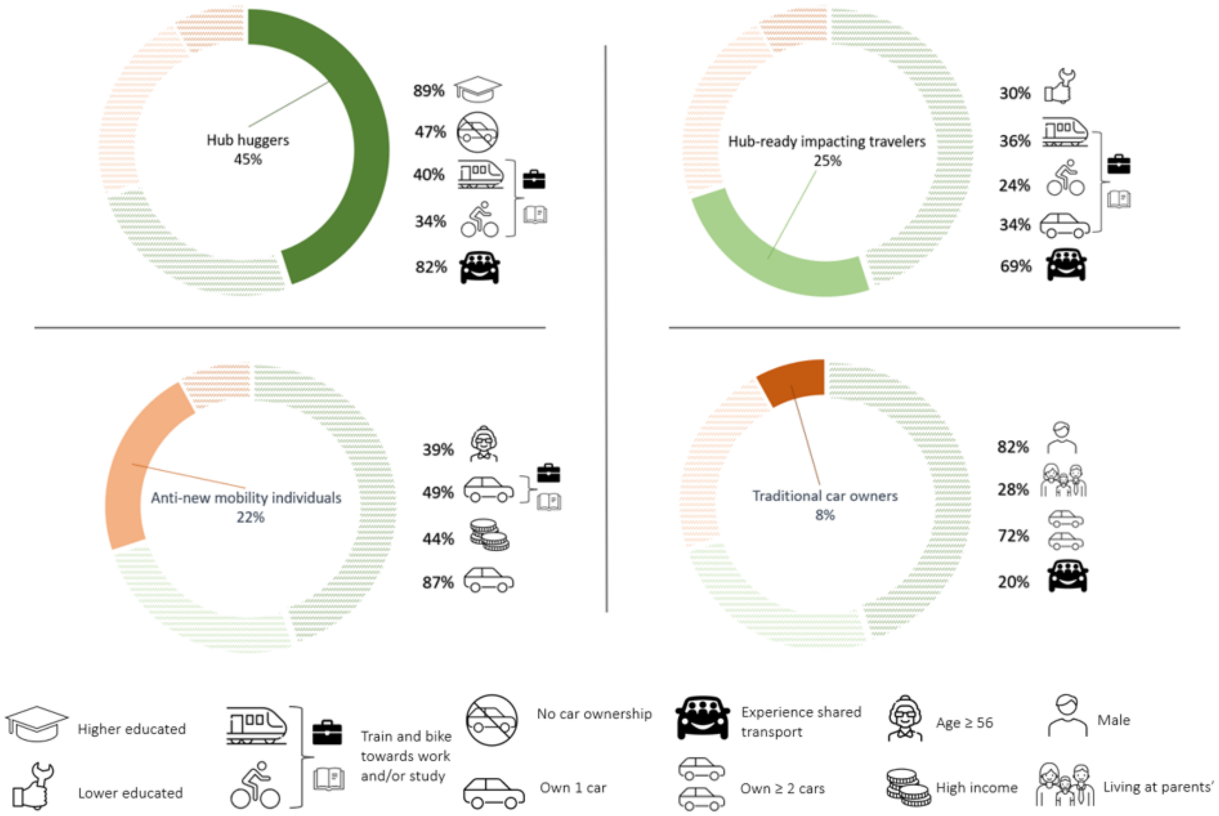


Figure 30: Visualisation of clusters and covariates

Cluster 2: Hub-ready impacting travelers
The second cluster consists of 25% of the sample. Except for the score of facilitating conditions the indicator scores for these indicators are closely related to the scores of cluster 1. This means that the people in this cluster have an aptitude to make use of mobility offered by a mobility hub, but may still need some assistance with making reservations, paying using their phone or just don't always have a stable internet network on their mobile phone. Regarding education, this cluster has the highest share (30%) of lower educated people. 36% of the cluster households doesn't own a car, the rest of the cluster members owns minimal one car per household. The cluster members are not necessarily tied to their car to get to work or study: 34% uses their car, 24% goes by (e-)bike and 36% takes the train. This fits well with the high score for environmental concerns. Due to the presence of a mobility hub, 29% of the cluster is expecting to use their car less often. 20% expects to sell their second owned car, and 11% expects to sell their only owned car, which is the highest among all clusters. Of all clusters, this cluster will therefore have the greatest impact in terms of car use and ownership. This may have to do with the lower share of students (resp. higher incomes and age; compared to cluster 1), and a higher percentage of two cars (or more) per household. The persons in cluster 2 can therefor make an actual impact on car usage and ownership in its neighborhood.

Cluster 3: Anti-new mobility individuals
The third cluster consists of 22% of the sample and members are typical *anti-new mobility individuals*. This is characterized by, among other things, the lowest score for facilitating conditions, which means that the people in this cluster have the most difficulty using their mobile phone for payments or making reservations. Moreover, persons in this cluster have the highest scepticism about new technologies. Their intention to use neighborhood mobility hubs has the second lowest value of all clusters. The cluster is characterized by all age groups, but to a lesser extent the youth (18-25 years old). Besides, a higher share (39%) of individuals older than 56 is present in the cluster. A large part of the clusters' households live together (with or without children), and 85% of the cluster members have a job. The cluster consists of households of which 87% has minimal one car. This also explains the high car percentage (49%) to travel to work and/or study. The people in this cluster have little interest for changing their travel behavior, since 64% thinks that a mobility hub will not change their car usage in the future. In addition, 9 percent of the 'anti-new mobility individuals' think that the presence of a hub ensures that

their second car is sold, 6 percent think that their only owned car will be sold. Above aspects of the difficulty of using the mobile phone, the scepticism of using new technologies, together with the higher share of older people who do not intend to change their travel behavior in the future result in the typical anti-new mobility individual.

Cluster 4: Traditional car owners
The fourth and last cluster (8% of the sample) consists of the *traditional car owners*. The behavioral intention to use hubs as well as the mobility hub beneficials are the lowest among all clusters. The members of this cluster thus have little aspirations to make use of mobility hubs in the future. The cluster consists of mainly men (82%) and 92% of the households in the cluster has minimal one car, 72% has two cars or more in its possession. This high car ownership may be related with household income, since 45% of the households in this clusters owns more than €50.000 a year. Furthermore, the majority of the cluster has no experience with shared mobility in the past. What strikes is that besides the car (36%), also the (e-)bike is a popular mode of travel towards work or study (36%). This may be explained by the share of people who live at their parents and possibly use their (e-)bike to school. This corresponds well with the share of people for car availability which needs consultation within the household to take the car. 71% of the members in the cluster believe that the presence of a mobility hub in their neighborhood would not affect their car usage in the future. They would still make use of their car, no person would sell their only owned car in the household, 4% would sell their second owned car in the household. Among others, the low intentions to make use of hubs together with the degree of car ownership and car usage of the cluster ensures that the members of this clusters are called 'traditional car owners'. This is reinforced by the prospect that people in this cluster is expecting to keep using their car in the future and will therefore not be able to say goodbye to the car.

Table 20: 4-cluster model including its active and inactive covariates

	Hub Huggers	Hub-ready impacting travelers	Anti-new mobility individuals	Traditional car owners	Sample %
Cluster Size	45%	25%	22%	8%	
Indicators (mean)					
Mobility hub beneficials	**3.69**	3.43	2.69	2.36	
Facilitating conditions	**5.00**	4.01	3.76	4.82	
Individual innovation scepticism	1.43	1.52	**2.53**	2.38	
Social-Environmental responsibility	**3.45**	3.38	2.73	2.36	
Behavioral intention	**3.66**	3.62	2.35	1.94	
Active covariates					
Age					
18-25	**44%**	30%	8%	36%	32 %
26-35	**41%**	25%	21%	20%	31 %
36-45	7%	13%	14%	20%	11 %
46-55	7%	13%	18%	16%	11 %
56-64	2%	17%	27%	4%	11 %
65+	0%	3%	12%	4%	4 %
Education					
Primary- or secondary education	9%	7%	5%	0%	34 %
MBO, or similar	2%	**30%**	13%	24%	39 %
HBO / WO Bachelor or similar	54%	27%	43%	52%	28 %
Master's Degree	35%	36%	39%	24%	36 %
Work situation					
I work full time	55%	48%	**52%**	48%	52 %
I work part time	12%	30%	**33%**	8%	21 %
I am unemployed, looking for a job or unfit for work	0%	4%	3%	8%	2 %
I am retired	0%	3%	8%	8%	3 %

I am a student	32%	15%	5%	28%	22 %
Household income					
<€20.000	23%	17%	2%	8%	16 %
€20.000 until €30.000	6%	4%	11%	0%	6 %
€30.000 until €40.000	14%	22%	13%	19%	16 %
€40.000 until €50.000	13%	12%	14%	0%	12 %
€50.000 until €100.000	27%	29%	39%	33%	31 %
€100.000 or more	8%	6%	5%	12%	7 %
I would rather not say	10%	10%	15%	28%	12 %
Car ownership					
No car	47%	36%	13%	8%	34 %
One car	40%	37%	**46%**	**20%**	39 %
Two cars or more	13%	27%	**42%**	**72%**	28 %
Travel behavior towards work or study					
Walking	1%	0%	8%	0%	2 %
(e-)bike	**34%**	**24%**	11%	**36%**	27 %
Bus/tram /metro	4%	5%	0%	12%	4 %
Train	**40%**	**36%**	25%	12%	33 %
Car	20%	**34%**	**49%**	**36%**	31 %
Moped	1%	0%	0%	0%	0 %
Other	1%	0%	8%	4%	2 %
Experience shared transport					
Yes	**82%**	69%	50%	20%	66 %
No	18%	31%	50%	**80%**	34 %

Inactive covariates					
Gender					
Female	43%	44%	31%	16%	38 %
Male	57%	57%	66%	84%	61 %
I'd rather not tell	0%	0%	3%	0%	1 %
Household composition					
Single	19%	11%	17%	8%	15 %
Living together, without children	36%	38%	**43%**	29%	37 %
Living together, with children	13%	27%	**32%**	28%	22 %
Single with children	1%	1%	2%	0%	1 %
With roommates / student house	28%	20%	6%	8%	20 %
With my parents	3%	3%	0%	**28%**	4 %
Urbanity					
Very strongly urban	**57%**	43%	28%	24%	44 %
Strongly urban	15%	21%	27%	36%	21 %
Moderately urban	6%	13%	9%	4%	8 %
Little urban	10%	12%	16%	16%	12 %
Non-urban	3%	5%	6%	4%	4 %
No postalcode	9%	7%	14%	16%	10 %
Do you have easy access to a car?					
Yes, whenever I want	31%	48%	69%	55%	46 %
Yes, in consultation with my hh	25%	23%	20%	36%	24 %
No, in consultation outside my hh	31%	18%	6%	4%	20 %
No, then I should rent / use shar. car	13%	12%	5%	4%	10 %

Effects of mobility hub					
The presence of a mobility hub will result in less own car usage					
Completely disagree	9%	5%	**27%**	**40%**	15 %
Disagree	13%	19%	**37%**	**31%**	21 %
Neutral	12%	19%	15%	8%	14 %
Agree	17%	**19%**	11%	8%	15 %
Completely agree	8%	**10%**	1%	0%	6 %

Not applicable to me	41%	28%	9%	12%	29 %
The presence of a mobility hub will make me sell my only car					
Completely disagree	14%	14%	32%	48%	21 %
Disagree	17%	27%	32%	28%	24 %
Neutral	10%	18%	19%	12%	14 %
Agree	8%	**8%**	6%	0%	7 %
Completely agree	1%	**3%**	0%	0%	1 %
Not applicable to me	50%	30%	11%	12%	33 %
The presence of a mobility hub will make me sell my 2nd (or 3th) car					
Completely disagree	4%	6%	19%	28%	10 %
Disagree	1%	5%	11%	16%	5 %
Neutral	4%	16%	16%	20%	11 %
Agree	10%	**12%**	6%	4%	9 %
Completely agree	7%	**8%**	3%	0%	6 %
Not applicable to me	75%	53%	44%	32%	59%

Sub-question 4: Which user clusters can be identified and what effect do these clusters have on car ownership?

From the LCCA, four different clusters can be identified, each explained below.

Hub huggers - 45% of the sample
The *hub huggers* have the highest intention to use mobility hubs in the future, with the highest scores for all indicators (resp. lowest score for facilitating conditions), indicating that the intention to use neighborhood mobility hubs is high. The cluster consists of relatively young people (<35 years old) who have had a higher education (89%). The majority of the sample has a job (full-time or part-time) or is still studying. The latter probably justifies why 47% of the sample does not own a car. Of the sample, 82% has used shared transport in the past and the current travel behavior towards work and/or study is mainly done by train or (e-)bike. The possible effect of a future hub on car usage and car ownership is not the highest among all clusters, but still relatively high: 25% of the cluster members indicate that they would use their car less when a hub is present, 17% would sell their second car in the household and 9% would sell their only car.

Hub-ready impacting travelers - 25% of the sample
Members of this cluster also have relatively high indicator scores, except for the score on facilitating conditions. This means that *Hub-ready impacting travelers* still need some guidance when making reservations and/or paying with their phone. Of the cluster members, 30% has a low level of education. 36% of the cluster households doesn't own a car, the remaining members own at least one car per household. Regarding travel behavior towards work and/or study: 34% uses their car, 24% goes by (e-)bike and 36% takes the train. The share of people who already have used shared transport is also quite high: 69%. Due to the presence of a mobility hub, 29% of the cluster expects to use their car less often, 20% expects to sell their second car and 11% expects to sell their only car, which is the highest among all clusters. Therefor, in comparison, this cluster will have the greatest impact in terms of car use and ownership. This may be due to the lower share of students (compared to *hub huggers*) and a higher percentage of more than two cars per household.

Anti-new mobility individuals - 22% of the sample
This cluster consists of cluster members which are not (yet) willing to use hubs in the future, characterized by the lowest score for facilitating conditions meaning that the people in this cluster have the most difficulty using their mobile phone. The cluster contains all age groups, with a relative higher share (39%) of individuals older than 56. The scepticism of using new technologies paired with the higher share of older people who do not intend to change their travel behavior in the future, result in the typical anti-new mobility individual. The cluster consists of households who live on a varying level of urbanity and of which 87% has minimal one car. This also explains the high car percentage (49%) to travel to work and/or study. Of these cluster members, 44% have a high households' income of > 50.000 euros/year. The people in this cluster have little interest in changing their travel behavior, since 64% thinks that a mobility hub will not change their car usage in the future. In addition, 9% of the 'anti-new mobility individuals' think that the presence of a hub ensures that their second car is sold and 6 percent think that their only car will be sold.

Traditional car owners - 8% of the sample
The behavioral intention to use hubs as well as the mobility hub beneficials are the lowest among all clusters. This means that the members of the cluster have little urge to make use of mobility hubs in the future. The cluster consists of mainly men (82%) and car ownership is high: 92% of the households have at least one car, 72% own two cars or more. Furthermore, the majority of the cluster has no prior experience with shared mobility. Besides the car (36%), the (e-)bike is also a popular mode of travel towards work or study (36%), this may be explained by the share of people (28%) who live at their parents' house and possibly use their (e-)bike to school. The effect on car usage and ownership is very limited: 71% of the members in the cluster think that the presence of a mobility hub in their neighborhood would not affect their car usage in the future. They would still make use of their car; no person would sell their only car in the household, 4% would sell their second car.

6 Conclusion

This study aimed to identify the user groups who are likely to adopt mobility offered by neighborhood mobility hubs. A neighborhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations which are within walking distance of home. A connection with public transport as well as other types of services (mobility and non-mobility related) is possible but not required. A mobility hub is an emerging concept in science and practice and, as a result, a lot of knowledge still needs to be gained. Existing literature lacks research into neighborhood mobility hubs and its users in particular. The success of a mobility hub depends mainly on the usage of the traveler. This research therefore investigated the behavioral intention to use mobility offered at neighborhood mobility hubs. This was done on the basis of four sub-questions, by selecting the most appropriate technology adoption framework, distributing a survey in the Netherlands (N=298) and analyzing the results using an exploratory factor analysis and a latent class cluster analysis.

The general results showed that people's intention to use neighborhood mobility hubs is quite high: 48.6% of the sample intends to use a mobility hub when it is available in their neighborhood. When the walking distance from home to the hub is specified to a maximum of five minutes, even 64.5% is willing to use it. These results are more positive in comparison with the (potential) usage of shared transport, MaaS or mobility hubs in general. The results are less encouraging when it comes to the effects of neighborhood mobility hubs on car usage and ownership. Of the sample population, 21.4% states that they intend to use their car less often when a mobility hub is present in their neighborhood. The effect on car ownership is slightly lower: 8% expects to sell their households' sole car, while 14.8% thinks that they will sell their second or third car.

This study has identified four different clusters in relation to individuals' intention to use neighborhood mobility hubs: 1) *hub huggers*, 2) *hub-ready impacting travelers*, 3) *anti-new mobility individuals* and 4) *traditional car owners*. Two of the four clusters have high intentions to use neighborhood mobility hubs in the future: the *hub huggers* (45% of the sample) and *hub-ready impacting travelers* (25% of the sample). The other two clusters, *anti-new mobility individuals* (22% of the sample) and *traditional car owners* (8% of the sample), are not yet ready to use neighborhood mobility hubs. The LCCA shows that in particular three indicators have a great influence in determining the intention to use hubs:

- The indicator **mobility hub beneficials** (performance expectancy, effort expectancy and hedonic motivation) appears to be highly related to the behavioral intention to use neighborhood mobility hubs. People who intend to use mobility offered at mobility hubs state that these hubs can improve their travel performance, are free from effort and fun to use.

- Neighborhood hubs are also positively associated with people who have a **social-environmental** mindset. Residents who are concerned about the environment, those who see potential in mobility hubs to contribute to a better climate and appreciate the opinion of others are more intending to use mobility hubs in the future. People who have a lower intention of using mobility hubs score low on both indicators mentioned.

- Lastly, the indicator **individual innovation scepticism** showed to be related to the intention to use hubs. The clusters that intend to use hubs, experience a low level of individual innovation scepticism, meaning that the clusters consist of people who are curious to try out new things, like to experiment with new services and usually take the lead in trying out new technologies. The opposite is visible for people in the clusters that have lower intentions to use hubs; they are more sceptic about innovations.

Besides these indicators, this research revealed that people who have prior experience with shared modes of transport have a higher intention to use hubs than people who have not. Moreover, it can be concluded that of the people who do not intend to use hubs, a large share owns at least one car. Unsurprisingly, clusters with a higher intention to use hubs have a higher share of households that do not own a car. Thirdly, the findings show that people currently travelling by (e-)bike and train show a large potential for using mobility hubs in the future. The profiles of the clusters with a higher intention to use hubs show a large share of people traveling by train or by (e-)bike, whereas clusters with a low(er) intention to use hubs have a larger percentage of people traveling by car to their work and/or study. This is in line with previous research: multiple other studies into MaaS mentioned PT users as early adopters of the technology (Alonso-González et al., 2020; Horjus, 2021; Van 't Veer, 2021; Zijlstra et al., 2019).

In previous research regarding the intention to use shared mobility, MaaS and mobility hubs, most users were young, highly educated and living in urban environments. This does not fully conform with the outcomes of this research. The largest cluster, *hub huggers*, show a large proportion of young (18-35 years old) people who are highly educated and mostly live in urban residences. However, when looking at the cluster *hub-ready impacting travelers* also other age categories intend to use mobility hubs, as well as lower educated people. This is a typical example of a situation where a LCCA shows its potential: no general conclusion but rather a focus on characteristics of different groups so tailor-made decisions can be made.

Regarding the effects of the different clusters on future car ownership, it can be concluded that the *hub-ready impacting travelers* have the greatest potential impact on future car use and ownership. The main difference with the *hub huggers* is that the *hub-ready impacting travelers* consist of a lower share of students (resp. higher incomes and age) and consequently a higher share of two cars (or more) per household. Moreover, cluster members of *hub-ready impacting travelers* live in a lower degree of urbanity. This makes that the potential impact on car ownership is higher among members of *hub-ready impacting travelers*. This implies that people are more inclined to sell their second (or third) car than when it is their only car. A point of attention here may be that members of the two positive clusters do not use their car as their main mode of travel, but also rely on their (e-)bike or train to reach their destination. Thus there is a risk that the offering of a mobility hub may cause an adverse effect: travelers may give up the use of PT and their (e-)bike instead of their car. Yet, this may make it more appealing for them to remain carless, which is a win-win situation. Another conclusion can be drawn for the *anti-new mobility individuals* and *traditional car owners*. These clusters are clearly not as eager in terms of reduced car usage and car ownership: neither the second (or third) car nor the households' only car have a good chance of being replaced by mobility offered at a mobility hub.

Finally, to answer the main research question on which user groups can be identified in adopting mobility offered by neighborhood mobility hubs, four clusters can be distinguished: 1) hub huggers, 2) hub-ready impacting travelers, 3) anti-new mobility individuals and 4) traditional car owners. These different clusters have all been characterized by the indicators: mobility hub beneficials, facilitating conditions, individual innovation scepticism and social-environmental responsibility. Moreover, the intention to use neighborhood mobility hubs can be identified using the characteristics age, education, work situation, household income, car ownership, travel behavior towards work and/or study and past experience with shared transport.

All together, the findings of this research indicate that a successful uptake of neighborhood mobility hub services seems realistic for many people and is a potential game changer for urban mobility. Two of the four clusters show a positive behavioral intention to use mobility offered at mobility hubs, consisting of 70% of the sample in total. People who currently use a sustainable travel mode to travel to *work and/or study* are more likely to be the adapters of neighborhood mobility hubs, as well as people who have prior experience with shared transport. Moreover this applies for people who have a social and environmental responsibility, innovative mindset and clearly see the benefits of using a mobility hub and which are (most often) higher educated and younger of age. Now that this research showed that neighborhood mobility hubs have the potential to play an important role in future transportation systems, it is now up to the authorities and companies to put the findings into action.

7 Discussion and Recommendations

In this section, first several limitations of this thesis are discussed, after which the implications of this research will be described, focussing on the scientific and practical implications. Lastly, some recommendations for future research and practise are presented.

7.1 Limitations

This research consists of several limitations that need to be taken into account when interpreting the results:

First of all, the sample was not fully representative of the Dutch population. When distributing the survey, the idea was to focus on respondents mainly living in higher density areas. This succeeded, however considering the researchers' personal and professional surroundings the sample contains of many younger, highly educated and higher income respondents. This overlaps well with the stereotypical shared transport user as defined in past studies. In turn, this could lead to an overestimation of the intention to use mobility offered at mobility hubs on one side. Consequently, this has probably led to an underestimation of the members of the clusters that do not intend to use mobility hubs. For instance, the cluster 'traditional car owner' consisted of only 8% of the sample, which would likely be larger when looking at the whole Dutch population.

The hypothetical bias that comes with using stated preference methods is also one of the study's limitations. When defining the conceptual model, it was decided to exclude the factor 'use behavior'. This was done because mobility hubs are not yet implemented on large scale, which makes the prediction of 'use behavior' difficult. Consequently, behavioral intention was the construct to be measured, resulting in a stated choice study. While stated choice experiments are an opportunity to capture preferences about new alternatives (e.g. mobility hubs), there is a risk that uncertainty and expectations are influencing the choices made. Respondents might develop a different attitude towards these services once they become more familiar with them. This leads to the misconception that people express their intentions to use mobility offered at mobility hubs, which simultaneously does not necessarily mean that they would actually make use of it. This may result in bias and an overrepresentation of the people who intend to use mobility hubs.

Furthermore the survey did not allow respondents to substantiate their choices. Because of this, it is unknown what the motivations of the respondents were behind choosing their private car instead of shared mobility, or the reason behind keeping (or selling) their least used (second) car. By leaving out the motivation of respondents, it might be more difficult to fully understand their decisions. This information may be important for the further development of neighborhood mobility hubs.

Regarding the subjective opinion of the researcher, the unintentional influence he has had on the process should be taken into account. This is, for instance, reflected in the choice of questioning, choice of answering options and choice of words in describing the mobility hub. Despite the fact that most choices are substantiated by literature and the overall neutral attitude of the researcher, it is possible that participants were influenced by the researcher's attitude.

Finally when executing the Exploratory Factor Analysis, the construct *price value* was deleted from the model due to too low communality of the first statement and too high factor cross-loadings of the second statement. *Price value* was the most difficult construct to decide on the statements, since the concept of a mobility hub is still in the early adopter stage and not much can be said yet about the pricing strategies. It is possible that the chosen statements regarding *price value* were not fully adequate to get proper outcomes. Moreover, where all other constructs had at least three statements per indicator, *price value* had only 2 statements. All of these reasons might have contributed to the exclusion of *price value* in the model.

7.2 Implications

The following section explains the implications, i.e. what consequences the research will have related to science and practice.

7.2.1 Scientific implications

The Latent Class Cluster Analysis is a method that is not much used in the transportation domain. To the author's careful knowledge, this study is the first study that executed a LCCA to explore the different clusters related to the intentions to use a neighborhood mobility hub. In most previous research into intention and willingness to use MaaS, shared transport and mobility hubs, often a stated choice experiment was executed. The advantage of a latent class cluster analysis over a stated choice is that different classes in the sample population are estimated, instead of making general conclusion over the whole sample population. Few assumptions have been made before and during the execution of the methods used in this research. First of all, it has been chosen to use an exploratory factor analysis, instead of a confirmatory factor analysis. This had consequences for the factors that have been explored, since it resulted in two combined factors and one that was negatively loaded. Yet, the EFA is a technique which stays close to the data, instead of confirming whether the data is experiencing the same relationships as the conceptual model (which is the case in CFA). The EFA thus resulted in more realistic factors for the sample population. Secondly, When performing the LCCA, determining the number of clusters needed some attention. Following the initial methodology, the 10-cluster model was the model which was most suitable for the data. Given the number of clusters this was not desirable and it was decided to compare the percentual difference of the BIC(LL) value between clusters. This resulted in a 4-, 5- or 6-cluster model as the most suitable models. Subsequently, the 4-cluster model was chosen because it was the best interpretable model having the most distinguished classes and the size of the different clusters was acceptable. However, cluster 4 still consists of 24 members which is quite low. Due to this small number of members, the resulting findings might be sensitive, since the indicator and covariates are based on a low number of members. Because of above mentioned assumptions and clarifications, further research might be needed to build upon the results of this study and reproduce the findings to make the scientific basis stronger.

This thesis builds on one of the recommendations of the study of Vianen (2022); to use an empirical way to gain more insights into residents or users of neighborhood mobility hubs. The UTAUT2 model was used as a basis for this empirical study. Other studies in the shared transport domain recently used the UTAUT model in order to study the willingness to use MaaS (Van 't Veer, 2021) and the acceptance and use of a bicycle sharing system in Iran (Jahanshahi et al., 2020). Because the Exploratory Factor Analysis has combined several indicators in this study, not every indicator can be compared with previous research. The study of Van 't Veer (2021) found that facilitating conditions indeed have an effect on MaaS, as well as effort expectancy and the indicator utility (combination of performance expectancy and habit). The study of Jahanshahi et al. (2020) found that, among others, performance expectancy, social influence and facilitating conditions contributed to the intention to use a bicycle sharing system. These findings, combined with the findings of this study, show that the UTAUT2 model is a suitable model to serve as a theoretical basis for innovations in the shared transport domain.

This paragraph focuses on the user characteristic findings and how they relate to the existing literature. This research brings attention to different user characteristics that influence the intention to use neighborhood mobility hubs in the Netherlands. The role of different moderators is examined in order to gather more information about the user characteristics influencing the intention to use neighborhood mobility hubs. Findings of previous research indicated that travelers who currently travel using public transport or active modes are potential users of MaaS (Van 't Veer (2021), Alonso-González et al. (2020)) and mobility hubs (Horjus (2021)), which is confirmed by this research. This study does indicate that current train travelers and cyclists have a higher intention of using neighborhood mobility hubs, however other types of public transport or active modes were not found to be related to user intentions. Furthermore, this study showed that travelers who already have past experience with shared transport are indicated to have an higher intention to use hubs, which is confirmed by Kreemers et al. (2021) and Horjus (2021). The findings of this research related to the higher level of education of future hub travelers is in line with other research (Bösehans et al., 2021; Horjus, 2021; Knippenberg, 2019; Liao & Correia, 2019), as well as that potential hub users typical live in denser environments (Claasen, 2020; Van Rooij, 2020) and are mostly younger of age (18-35 years old) (Bösehans et al., 2021; Horjus, 2021; Miramontes, 2018). Previous studies indicated that men are the main (future) users of shared transport (El Zarwi et al., 2017). This study however showed that women have a higher intention of using in particular e-bikes and cargo bikes. This is therefor an interesting result, which unfortunately could not be compared with other studies since these shared modal data is not available. The finding mentioned above show that a number of factors of the UTAUT2 model as well as the user characteristics apply in the case of neighborhood mobility hubs. Besides general findings from the sample population, this research also contributed to build scientific knowledge on the different clusters examining the intention to use neighborhood mobility hubs. Two of the four clusters (accounting for 70% of the sample) have the intention to use mobility hubs, while the other two clusters do not intend to use hubs. This does not mean that they will never use shared transport from hubs in the future; tailor-made policies per cluster may help to increase the future adaptation of neighborhood mobility hubs.

Lastly, among others, the variables age, education and the degree of urbanity have shown to influence the intention to use mobility offered at mobility hubs. Since the younger, higher educated people living in urban environments are overrepresented in relation to the Dutch population, it is likely that their intentions of use turned out somewhat higher in the positive clusters than reality would show. This is specifically the case for the *hub huggers*, since most of the members of this cluster are young, highly educated and live in an urban environment. For the *anti-new mobility individuals*, an underrepresentation of the younger age group has likely caused the intention to use mobility hubs to be lower on average in this research than it would be in the Dutch population. Further research is needed in areas with a diverse population in term of e.g. age, education and density in combination with their intention to use hubs in order to give more representative results of the Dutch population.

7.2.2 Practical implications

This study has several practical contributions related to the general results and the cluster findings. This study revealed that travelers with sustainable modes of transport (train and (e)-bike) as well as prior experience of using shared transport are a determinant for using mobility hubs. These findings can be used to reduce car usage and car ownership. Stimulating the adoption of mobility hubs among people that use other modes, such as the car (or other less sustainable modes of transport) is a good first step. The adoption of hubs by car owners in particular can be stimulated in multiple ways. One possibility may be to offer car owners (or all residents of the neighborhood) a discount and free rides when the hub is introduced in the neighborhood, so that they can get acquainted with the concept in an affordable way, while also gaining experience. Another policy measure might be to allow car owners to temporarily trade in their car in return for a large discount on a mobility hub subscription. This way, a gradual shift is proposed using both the sustainable mode of travel and the experience of the traveler with shared transport. Accompanying policies, such as discouraging owning a car, can thus have an effect on the speed of adoption. However, a disadvantage is that it can also affect the composition of the group of clusters.

This study distinguishes clusters in the sample population that are different in user characteristics and indicator scores. This study contributes to practice by determining hub implementation strategies that could be specified per cluster(s). For example, in the clusters *hub-ready impacting travelers* and *anti-new mobility individuals* it is noticeable that the indicator facilitating conditions is relatively low. This means that people in those clusters have issues with one or more of the following actions: (1) having difficulty with the operation of their smartphone, (2) don't always carry their mobile phone with them, (3) don't always have a stable mobile network or/and (4) have difficulty doing payments on their phone. For a hub provider it is beneficial to take this into account when implementing a mobility hub in the neighborhood by offering clear instructions on how to use the mobility hub. Step-by-step instructions have to be made on how to make reservations with your phone, how to do payments and how to (un)lock the different modes of transport. Another (out of the box) option is to allow for smartphone-free usage in the reservation and payment process. Reservations and payments could for example be done using a ticket vending machine, equipped with touchscreen which is located at the mobility hub. Another option is to do the payments and reservations at a local store or supermarket close to the hub.

One of the limitations showed that the research sample is not fully representative within the Dutch population and cluster sizes may be different. However, this does not indicate that the results of the analyses could not be estimated for the Dutch population. The contributions of this research are especially valuable when specifying different cities or regions. For example, when comparing the research sample with cities such as Amsterdam and Utrecht, in which residents have a high degree of urbanization (CBS Statline, 2020b), are typically younger of age (CBS, 2022) and higher educated (CBS, 2020a) the results of the cluster analysis might be the same in practise. The transferability of the results to other contexts is expected to be limited. When looking at regions having a lower degree of urbanization, distances traveled are larger en often the PT network has a lower quality. This might result in cluster sizes that will be different or different clusters will be found. Here it is likely that that the sample size of *hub huggers* is (much) lower and the size of *traditional car owners* is higher.

In the analysis, an interesting finding occurred related to the maximum walking time respondents intend to walk towards a mobility hub. 48.6% of the respondents intend to use a mobility once available in their neighborhood, while 64.5% intend to use the hub once the walking distance is limited to five minutes. When the walking time towards a hub is less than 10 minutes, 35.9% of the respondents intends to use it (Appendix F, Figure 31). It is apparent that respondents were more negatively associated with the first statement, but did have a stronger opinion when the condition of 5 minutes walking time is added. A walking time of less than 10 minutes is least favorite for the potential users. This is in line with previous research of Van 't Veer (2021) into MaaS, were the willingness to use MaaS services was higher (walking time of 2 minutes) or equal (walking time of 5 minutes) when the walking time was limited, compared to leaving out walking time in the statements. Thus, the contribution of this research is that it has shed light on the intention to use hubs together with a walking time specification. The study indicates that the intention to use neighborhood hubs is highest among respondents when the walking time is limited to 5 minutes, while a limitation of 10 minutes is indicated as too much. In practice, these results might be useful in the development phase, by suggesting to find locations for a hub having this time limitation in mind. Because of the explorative manner of this study, this is only a suggestion so further research is recommended into future hub locations.

It should be noted that 47% of the members of *hub huggers* do not own a car, which might suggest a limited potential impact regarding car ownership. Moreover, the findings indicate that neighborhood mobility hubs may replace trips currently being made using private sustainable modes. *Hub huggers* is the cluster with the highest intention to use mobility hubs, however also consists of members which merely travel using the (e-)bike or train. There is thus a risk that offering the shared modes of a mobility hub will lead to travelers giving up public transport. However, it is more than just a switch from one mode to another and might lead to several limitations: 1) a sustainable way of travelling might be replaced by another sustainable travel mode, which makes the effect of a hub on car ownership limited, 2) when switching from public transport or an (e-)bike to a shared car, no improvement will be made in terms of space use or emissions and 3) for the (e-)bike there is an additional downside, namely that the bicycle is exchanged for a less active mode of transport. On the other side: a low share of car ownership can also be beneficial for the cluster members. The arrival of a mobility hub in the neighborhood will give these people easier access to shared transport, which could mean that these people will remain car-free for a longer period.

As indicated above, the effect of the cluster *hub huggers* on car ownership and car usage is somewhat limited because of the large share of students and (consequently) smaller share of car owners. However, over time these students find a job and have to commute to work, which may then be done by car. Since this research has shown that past experience of shared transport and commuting using a sustainable (train and/or (e-)bike) mode contributes to an intention to use mobility hubs, it is likely that these people have a higher chance of using hubs, also after their period of being student. Of course mode-choice depends on many more factors, but this research provides a good first overview of elements that might be of influence when intending to use mobility hubs. Further research needs to be done to indicate whether these factors also occur with actual hub usage.

This study showed that the shared bicycle is one of the least favorable modes of transport respondents intend to use when a mobility hub is present at their neighborhood. This is probably caused by the Dutch context of this study, where most people have a bicycle at their home and therefore do not have a high intention of using shared bicycles from the hub. It should be emphasized that this could be different in other countries, e.g. lower bicycle ownership, which probably makes the influence of bike usage bigger. These contextual factors should however be taking into account when comparing results from different countries.

7.3 Recommendations

Several recommendations are given regarding future research and practise.

7.3.1 Recommendations for future research

The first recommendation entails further research into the facilities of a neighborhood mobility hub. This study mainly focused on the mobility aspect of a hub and hardly looked at the non-mobility related aspects. The only non-mobility related statement in the survey did not make it through the factor analysis. Since a mobility hub is not only a parking lot but also a meeting place with other non-mobility related facilities (such as parcel lockers, EV-charging, shops) further research is recommended to get a better idea of the degree of adoption when encountering the full package (mobility and non-mobility related aspects) of a mobility hub.

As already mentioned in the limitations section, this study did not give the respondents a possibility to explain their choices. Further research could focus on the reason behind respondents' choice in favor or against mobility hubs. This results in a more qualitative study into the behavioral aspects and choices of a potential hub user.

Furthermore, it is recommended to investigate the *actual* effects of a neighborhood mobility hub, by examining different UTAUT2 indicators of already implemented hubs, such as Hely hubs. Current study uses stated-preference data, but when using revealed-preference data a more reliable image can be sketched without bias. A few changes can be made to the current used model: 1) it is possible to use the construct 'use behavior' in the UTAUT2 model which was left out in the model, 2) using data based on revealed preferences ensures that the indicator price value can also be included in the model. Adding those indicators together with the usage of revealed data may result in more realistic clusters. Here it is important to have a large enough sample size, which may be difficult since there are still few hubs in the Netherlands.

As discussed in the implications section, tailor-made efforts per cluster could be made to get more people of that cluster familiar with shared mobility offered at mobility hubs. This study is a first step in the right direction by using clusters to define the different users. Since this research is not fully representative of the Dutch population, a recommendation would be to repeat the research on a larger scale, with a more representative sample. A paid survey can be carried out, to obtain a sample that better reflects the population. This does not necessarily have to be for the whole Dutch population but can certainly also add value by focusing on different cities, urbanity levels or specific user groups. When there are more representative clusters, the added value of a LCCA is even larger.

Just like this study, the majority of studies regarding neighborhood mobility hubs focused on urban areas. Owning a car is no longer a necessity in urban areas due to PT, shared mobility and the bike. However, section 3.1.1 indicated that a neighborhood mobility hub could also be stationed in rural neighborhoods. Specifically in areas where the distance between bus stops is high and the frequency of the service is low, mobility hubs could be an opportunity. Besides, car ownership is higher in rural places in comparison with urban areas (section 3.2), which may result in a higher impact of hubs on car ownership. A last recommendation for future research would therefore be to investigate the willingness to use (neighborhood) mobility hubs in rural areas.

7.3.2 Recommendations for practise

This research offers a number of handles that can be used in the development and realization of a neighborhood hub. First of all, it is advised to locate hubs close to people's homes, at a moderate walking distance (approximately five minutes of walking). Using this research' findings that potential hub users live in dense environments and ideally do not own a car, it would be wise for municipalities and/or practitioners to start developing neighborhood mobility hubs in inner-city neighborhoods. In this way, a lot of determinants are taken into account, which might lead to a successful uptake of a mobility hub.

Furthermore, the findings of this thesis can help municipalities and practitioners manage their expectations regarding potential hub usage and help set up strategies in launching and operating neighborhood mobility hubs. Alongside the use of the advice stated in previous paragraph, it is recommended in the development phase of neighborhood mobility hubs to start looking for potential neighborhoods using a demographic scan of different (inner-city) neighborhoods. This study showed that (among others) younger, higher educated people who live in dense environments have a high intention of using mobility offered at mobility hubs. These findings are valuable when executing a demographic scan of the neighborhood and thus may help with finding suitable neighborhoods.

Moreover, when neighborhood hubs are implemented, policymakers should actively encourage their use. As already indicated in the practical implications, residents might need a trigger to get them in to action and actually use the hub. This starts with bringing attention to the mobility hub through posters, letters or using the local newspaper. Furthermore when the hub is presented to the neighborhood, it could be a good idea to provide residents discounts and free trips so they can get a taste of the hub concept while also gaining experience. All of this could lead to the adoption of a mobility hub and all the advantages it brings.

This research focuses on the potential user groups of mobility hubs. However, it is not solely the users who are responsible for the diffusion of mobility hubs in the Netherlands. More actors are involved, such as governments and employers. When governments encourage or impose the use of a mobility hub, a completely different picture may arise. Local governments can, for instance, employ push factors to make owning a private car less desirable and free up space for other uses. Consider car-free zones, higher parking fees, and other regulations. It is also conceivable that employers will actively work with mobility hubs and oblige employees to use shared transport from the hub for business trips. The potential of mobility hubs is then much less dependent on residents, and much more dependent on the coercive attitude of the above-mentioned actors.

This research is part of a growing body of work in neighborhood mobility hubs. Nonetheless, action is the only way for change to occur. Now that more and more research has been done into the (potential) users of neighborhood mobility hubs as well as shared mobility and MaaS, it is now up to the authorities and companies to use its findings in practice. It is up to key stakeholders to make a difference and actively start working on developing neighborhood mobility hubs. Of course, numerous factors must be considered, from selecting possible locations within a neighborhood (taken into account the walking time) to the mix of vehicles offered at the hub. But above all, the most important aspect is the end-user. Examine the type of people who live in the neighborhood to see if they fit into either one of the two positive clustering results. Only when taking into account the user aspects, the concept of a mobility hub might reach its full potential.

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Appendix A Scientific paper

Intention to use neighborhood mobility hubs

Identifying user groups using a Latent Class Cluster Analysis

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Abstract—**Over the past decades, car ownership in the Netherlands has been on an increase. Besides being an environmental burden, passenger cars also require a lot of space. Mitigating the impact of passenger cars on climate change and public space requires a shift to a more sustainable view of transport, in which neighborhood mobility hubs might play a role. As a relatively new concept, mobility hubs are starting to gain attention in academia and practice. The first findings, however, showed that the adoption rate of mobility hubs might be low and no good image of the user can be formed yet. This research therefore aims to identify which user groups are likely to adopt mobility offered by neighborhood mobility hubs in the Netherlands. To do this, a conceptual model is based on the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) and subsequently, a survey was distributed in the Netherlands (N=298). After analyzing the data using an Exploratory Factor Analysis, a Latent Class Cluster Analysis was executed in order to find groups in the sample population with similar preferences and socio-economic profiles. By means of the latter, four distinctive groups of travelers are uncovered. Two clusters have intentions to use neighborhood mobility hubs: hub huggers (45%) and hub-ready impacting travelers (25%). The other two clusters, anti-new mobility individuals (22%) and traditional car owners (8%) are not yet ready to use neighborhood mobility hubs. There are some determinants that are likely to play a role in future mobility hub usage: people with prior experience with shared transport and households who do *not* own a car are more likely to use neighborhood mobility hubs in the future. People who currently use a sustainable travel mode (train or (e-)bike) to reach their work and/or study are more likely to be the adapters of neighborhood mobility hubs. This also holds for people who have a social and environmental responsibility, innovative mindset and clearly see the benefits of using a mobility hub and who are (most often) higher educated and younger of age.**

Keywords: neighborhood mobility hub, behavioral intention, exploratory factor analysis, latent class cluster analysis, UTAUT2

I. Introduction

A. Context

For years, the car has been a popular mode of transport: since 1990, car ownership in the Netherlands has increased from 0.8 to almost 1.1 cars per household (KiM, 2022). In 2020 8.7 million passenger cars were registered in the Netherlands, accounting for 49% of the total trips made (CBS, 2020). The transport sector as a whole contributes to climate change by being one of the largest sources of greenhouse gas emissions. Despite the fact that more and more electrical cars are introduced on the road, the total amount of CO_2 emissions of the transport sector is 28.50 million kilograms in 2018, of which 58% is caused by passenger cars (CBS, 2021). Due to the Paris agreements the transport sector needs to reduce their CO2 emissions by 60% in 2050, compared to 1990 (Ministerie van Economische Zaken, 2016).

Passenger cars are not only an environmental burden but they also require a lot of space compared to other modes of transport such as cycling and public transport (PT) (Natuur en Milieu, 2020). Since cars are generally parked for more than 90% of the time, a large number of motorized vehicles require a considerable amount of parking space (KiM, 2018). Parked cars and bicycles together occupy a large portion of public space, which can potentially also be used for public green spaces, housing or recreation.

To address these issues, offering shared mobility might lead to a solution in reducing car ownership. An important trend is the development of new means and forms of shared transport, in which a neighborhood mobility hub might play an important role. A neighborhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations which are available at walking distance from home. A connection with public transport as well as other types of services (mobility and non-mobility related) is possible but not required. These neighborhood hubs are of great significance in solving mobility problems in neighborhoods using sustainable transport. In this way, personal car use (and ownership) may be reduced by providing beneficial features (e.g. increased mobility, accessibility, flexibility) without the negative aspects (e.g. spatial use, high emissions, congestion) (Knaack, 2021).

B. Research problem

As a relatively new concept, mobility hubs are starting to get attention in academia and practice. However, the focus is mainly on medium to large-sized mobility hubs (such as train stations and park and rides) that are located in urban areas or at the edge of cities (KiM, 2021; Rijkswaterstaat, 2020). Moreover, the first findings show that the adoption rate of mobility hubs might be low (Claasen, 2020; Fioreze et al., 2019; Van Rooij, 2020). The success of a mobility hub depends mainly on the usage of the traveler. Because the literature into neighborhoods mobility hubs is still on a rise, no a good image of the user can be formed (Knippenberg, 2019; Van Rooij, 2020). A new user orientated approach is thus needed in order to contribute to a better adoption of the mobility hub. This research aims to contribute to that, by identifying *which user groups are likely to adopt mobility offered by neighborhood mobility hubs in the Netherlands.*

C. Scope

This research focuses on potential user groups related to neighborhood mobility hubs in the Netherlands. A survey was used to gather data. Neighborhood mobility hubs will mainly occur in urban residential areas and rural areas ((APPM and Goudappel, 2020)). The reason to research all potential users (and not just car owners) is to provide a complete picture of the user groups in the Netherlands. There is quite a difference in car ownership per region (CBS, 2018), in order to keep the study representative, all adults will therefore be able to participate.

D. Relevance

Since the amount of literature on mobility hubs is scarce, this study contributes to adding knowledge in this field. Moreover, this research contributes to add knowledge about user groups of shared mobility offered by neighborhood mobility hubs, their adoption potential and the effect on car ownership. The study of Molin et al. (2016) indicates that a latent class cluster analysis (LCCA) has been applied in the transportation domain but the number of applications is rather limited. No other study in the field of mobility hubs used this method before, to the author's knowledge.

The societal relevance contributes to the different user groups who are likely to adopt mobility hubs. In this way, knowledge is gained about these groups, which can be used by practitioners and municipalities to decide on tailor-made measures or policies. In addition, there will be more knowledge about the potential end user, which is very relevant for developers of hubs and area development. Eventually, this could lead to a reduction of car ownership which may result in a reduction of CO_2 emissions and a redesign of public space. But above all, an increase in the use of shared mobility contributes to a more sustainable place to live.

The remainder of this paper is structured as follows. In the next section, the methodology is explained by clarifying the steps taken for the literature study, exploratory factor analysis and latent class cluster analysis. In section III, the conceptual model and underlying indicators and moderators are shown and explained. In section IV the results of this study are presented, focusing on the general results, the factor analysis and the latent class cluster analysis. Section V provides the conclusions and the discussion of this paper.

II. Methodology

The sections below will discuss the main methodological steps undertaken in this research.

A. Literature review

To identify different user groups who are likely to adapt to mobility hubs, first a literature study was done into the factors that might influence the intention to use mobility hubs. The UTAUT2 model was used as a basis for this. Because the concept of hubs is quite new in academic literature, it was decided to broaden the search term regarding the intention to use neighborhood mobility hubs. Initially, literature was searched in the field of neighborhood mobility hubs and mobility hubs in general. If this search term did not provide enough information, it was broadened in the direction of MaaS and shared mobility. Eventually, a conceptual model was formed using the factors substantiated by literature.

B. Survey conduction

Data was gathered by conducting a questionnaire that consists of categorical questions, 5-point Likert scale questions and two open questions. For the questionnaire, a sample size of about 300 respondents is desirable in order for the data analysis to be valuable (Field, 2013). The majority of the respondents were collected using the researchers' personal and professional surroundings. Some of the respondents were approached on the streets of the Hague, Leiden or Utrecht. The respondents needed to be 18 years or older. The main part of the survey is based on the conceptual model of which 30 questions were asked about the indicators. Moreover, the questionnaire was used to get insights in the socio-demographical characteristics of the respondents, their current mobility pattern, whether they had past experience with shared transport and further questions regarding their intention to use mobility hubs in the future.

C. Exploratory Factor Analysis

After the data is collected, the data analysis starts. This however does not begin with a LCCA. First, a factor analysis needed to be executed. Factor analysis is a technique that can be used to (1) understand the structure of a set of variables and (2) to reduce the data set to a feasible size while keeping as much of the original information (Field, 2009). Moreover, a factor analysis makes it possible to execute a cluster analysis (Kootstra, 2004).
There are multiple types of factor analysis: Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis

(CFA). EFA is a variable reduction technique which enables that all measured variables can be related to every latent variable, so a relationship does not need to be substantiated by literature. An exploratory factor analysis is often used for instruments that have never been tested before (Osborne, 2014). The aim of a Confirmatory Factor Analysis is to establish to what extent the model fits the data and thus can be used for instruments that have been tested before (Osborne, 2014). Both factoring techniques have the goal of uncovering latent factors. A difference between CFA and EFA is that for CFA the variables are only able to load on the factor that was theoretically underpinned as a priori of the analysis, while for EFA no structure is known beforehand and any variable is able to load on every factor (Mueller and Hancock, 2001). Since this research aims to gain insight into the factors influencing a neighborhood mobility hub rather than checking whether the conceptual model holds, the Exploratory Factor Analysis was chosen for further analysis.

The EFA was run in IBM SPSS Statistics (version 28) using the Principal Axis Factoring and Direct Oblimin rotation technique. The first step in conducting an EFA is to check whether the sample size is large enough and if the respondents data is suitable. A sample size of about 300 respondents in needed to perform an EFA (Kass and Tinsley, 1979). Data suitability further needs to be checked using the Kaiser–Meyer–Olkin (KMO) (measure of the proportion of variance among variables that might be common variance, needs to be ≥ 0.50) and having a significant Bartlett's test of Sphericity (p-value < 0.05). To avoid high multicollinearity, which means that variables that are highly correlated, a determinant of the correlation matrix greater than 0.00001 is desired.

The determination of the number of factors is done using three measures: the Kaiser rule (eigenvalue > 1) that is verified by a scree plot. Furthermore, each factor must have at least three acceptable factor loadings (≥ 0.40).

After determining the number of factors, the next step is to determine which variables belong to which factor. This is checked using three criteria: the factor loading (≥ 0.30), the cross-loading ($\leq 75\%$ of highest indicator loading) and communality (≥ 0.20). When the amount of factors have been decided on, the reliability of the factors must be measured (using Cronbach's Alpha) in order to check the ability of the questionnaire to measure consistently (Van 't Veer, 2021). A high value of Cronbach's Alpha reveales if the items of each factor are coherent within the factor. According to Straub and Gefen (2004), a Cronbach's Alpha higher than 0.60 is acceptable for exploratory research.

The final step is to compute a factor score by summing up the variable scores that are related to the same factor and divide it by that specific number of variables (Schreiber, 2021).

D. Latent Class Cluster Analysis

Latent Class Cluster Analysis is a probabilistic-based clustering technique that segments and characterizes the socioeconomic profiles of population groups with similar preferences (Wang et al., 2021). Using LCCA, individuals are grouped in different classes (or clusters) according to an unobserved latent class variable that explains their responses on a set of observed indicators (Alonso-González et al., 2020; Molin et al., 2016). The advantages of LCCA include the use of statistical criteria to determine the optimal number of classes and the ability to deal with various scale types of variables (i.e. nominal, ordinal, continuous, count) and computing the significance of the model parameters (Magidson and Vermunt, 2002; Molin et al., 2016). Moreover, the probabilistic-based clustering mechanism introduces uncertainties when assigning individuals into different segments, generating more homogeneous segments than deterministic-based clustering techniques (Molin et al., 2016; Wang et al., 2021).

A LCCA model consists of two parts: 1) a measurement part where the latent classes explain the associations between the indicators and 2) a structural part where covariates are used to predict class membership of individuals (Magidson and Vermunt, 2016; Ton et al., 2020). The LCCA is executed using the software of LatentGOLD (v5.1). First, the measurement model is estimated, including only the indicators, by determining the appropriate number of classes (Ton et al., 2020). The overall goal is to find the most parsimonious model, so the model with the smallest number of latent classes, which can sufficiently describe the associations between the indicators (Molin et al., 2016). Various statistical tests are available to determine the optimal number of classes with the highest model fit: Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC) and Bivariate Residuals (BVR). For both BIC and AIC the guideline is to choose the number of clusters with the lowest value (Magidson and Vermunt, 2016). The Bivariate Residuals (BVRs) is a useful measure that provides information about the local model fit (Maarten Kroesen, 2021). A BVR value smaller than 3.84 is preferred, indicating that no covariation exists between two indicators (Molin et al., 2016).

When the number of clusters is determined, the structural model can be added to the model, so that the effects of the covariates (moderators) on latent class membership can be explored (Alonso-González et al., 2020). The procedure is as follows: first, all covariates are added to the model. By means of backwards elimination insignificant covariates (Wald < 3.84 or p > 0.05) will removed (and added as inactive covariates) (de Viet, 2019; Van 't Veer, 2021), starting with the most insignificant covariate. In the end, the significant covariates (Wald > 3.84 and p < 0.05) remain and are labeled as active covariates.

The final step is to check how accurately the model defines the classes, in other words, an estimate of the probability is given that each of the individuals is present in the different clusters. This is done using the entropy R-squared. Values above 0.80 indicate good classification of the individual cases into classes (Clark and Muthén, 2009), whereas a value below 0.60 is discouraged (Weller et al., 2020).

III. Conceptual model

In this section, the Unified Theory of Acceptance and Use Technology 2 (UTAUT2) model will be adapted to neighborhood mobility hubs and subsequently, factors affecting the intention to use mobility hubs will be investigated. The conceptual model will be used for investigating which indicators might influence the intention to use mobility hubs. This is the basis for determining which indicators will affect the clusters in the sample population. The UTAUT2 is a comprehensive model used to understand the acceptance of technologies. The UTAUT2 model is chosen because it builds upon eight proven technology acceptance models (Venkatesh et al., 2012), it has high prediction accuracy (Venkatesh et al., 2012) and has a focus on consumer technology, which was not accounted for in the UTAUT model (Straub, 2009). This makes the UTAUT2 model highly suitable for researching the adoption of shared transport offered by neighborhood mobility hubs.

The conceptual model can be found in Figure 1. As can be seen, eight indicators and eleven moderators are expected to influence the intention to use mobility offered by mobility hubs. The literature was explored to find the relationship... between the initial indicators of the UTAUT2 model and the intention to use (neighborhood) mobility hubs. Since the concept of hubs is relatively new in academic literature, also search terms in the direction of MaaS and shared mobility are used to substantiate the possible relationship. The conceptual model differs from the UTAUT2 model in that the construct habit and the latent variable use behavior are not included. Besides, two constructs are added that might influence the behavioral intention to use hubs: environmental concern and individual innovation.

It was decided to not include **habit** in the conceptual model. Habit is seen as prior behavior (Venkatesh et al.,

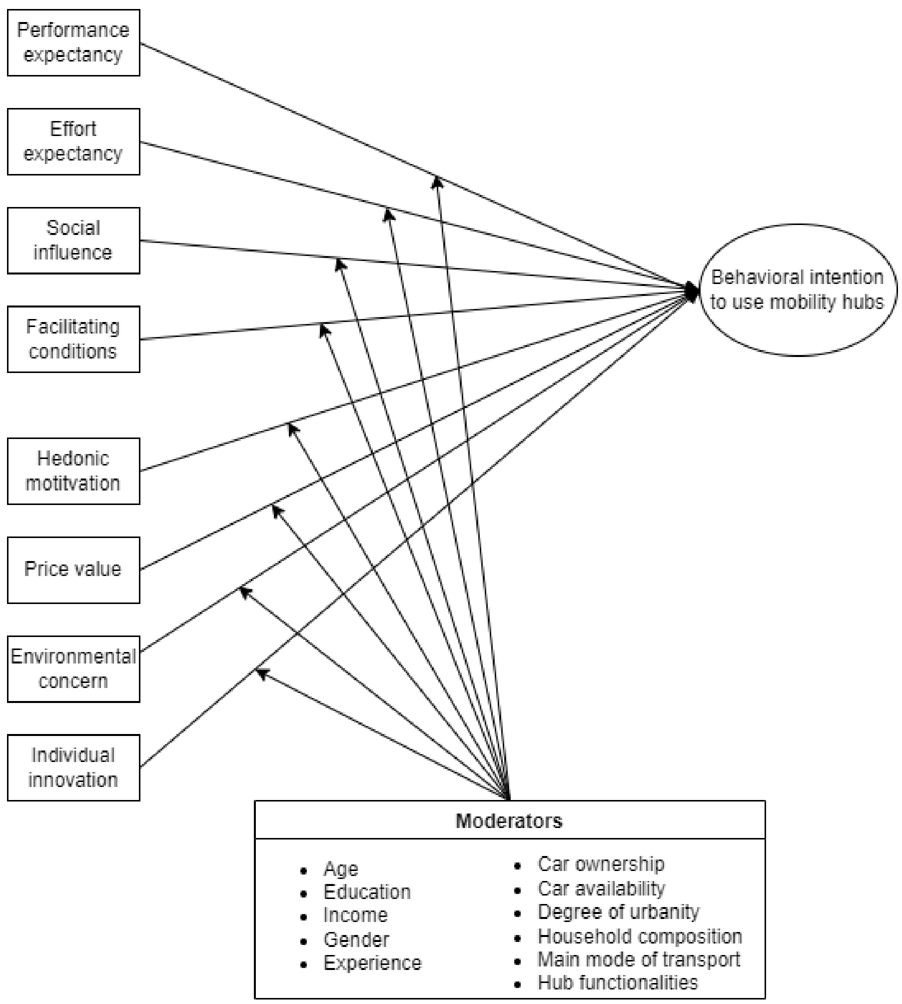

Fig. 1: Conceptual model regarding the intention to use mobility offered by mobility hubs

2012), which is hard to measure with technology that has not yet gained sufficiently widespread among users. Moreover, **use behavior** is not included in the model. Use behavior is defined as the use behavior measured from the actual frequency of using a technology (Venkatesh et al., 2003). Since mobility hubs are not yet implemented in the Netherlands on large scale and most users are still in the innovators stage, the measuring of usage behavior is not possible.

Below, the eight indicators that are expected to influence the intention to use neighborhood mobility hubs are described.

- **Performance expectancy** is defined by Venkatesh et al. (2003) as a degree to which a person believes that using new technology can improve his or her performance (in travel time and convenience). It is expected that performance expectancy is a predictor of the intention to use a sharing system (Fleury et al., 2017; Liang et al., 2018).
- **Effort expectancy** refers to the perception that using neighborhood mobility hubs is free from effort (Venkatesh et al., 2003). Previous research indicated that effort expectancy is an important determinant of intending to use car-sharing (Fleury et al., 2017; Tran et al., 2019).
- The same holds for **social influence**, in which an individual perceives that (important) others believe he or she should use mobility offered by mobility hubs (Kreemers et al., 2021; Venkatesh et al., 2003). Studies of Claasen (2020) and Burghard and Dütschke (2018) shows that a traveler's willingness to use shared mobility is affected by prevailing social norms.
- **Facilitating conditions** refers to the degree to which a person believes to be in control of the technical conditions of a mobility hub. These conditions are the skills that individuals have with their smartphones, the stability of the mobile network and the familiarity of individuals with mobile payments Ye et al. (2020). The findings of Horjus (2021); Van 't Veer (2021) result in the decision to include facilitating conditions into the conceptual model, by indicating that a higher degree of facilitating conditions will lead to a higher intention to use hubs.
- **Hedonic motivation** is defined as the fun or pleasure derived from using a technology (Venkatesh et al., 2012). It is expected that travelers with a positive hedonic motivation towards shared mobility offered by a hub are more likely to have positive intention to use the new system (Claasen, 2020; Kreemers et al., 2021; Tran et al., 2019).
- Furthermore, **price value** was included in the conceptual model for this research. The studies of Chen and Chancellor (2020); Du and Cheng (2018) both found that price value was an important construct regarding bicycle sharing. Although prices are a difficult domain in the innovator stage, such as mobility hubs, it is decided to include it in the model.
- **Environmental concern** is a newly added construct to the model and refers to the awareness of consequences or effects held by an individual on environmental problems (Fujii, 2006; Schultz et al., 2005). People who are environmentally conscious have stronger sustainable motivations Liang et al. (2018) and are more willing to participate in environmentally friendly activities (Gleim and J. Lawson, 2014). Since mobility hubs offers sustainable traveling, environmental concern is included in the model.
- **Individual innovation** is the ability of an individual to be skilled in discovering and accepting new technologies. It is assumed that highly innovative users are more open to new technologies and changes compared to less innovative users. This is confirmed by the study of Ye et al. (2020) and Back (2021), which indicated that a stronger individual's innovation contributed to a higher willingness to use shared mobility.

Lastly, several descriptive variables are added to the model, which are expected to influence the relationship between a constructs and the intention to use. These variables are: age, education, income, gender, experience, car ownership, car availability, work situation, degree of urbanity, household composition, main mode of transport and hub functionalities.

IV. Results

In total 314 respondents filled in the survey, of which 298 completed it (response rate = 95%). Respondents who did not fully complete the survey were deleted from the sample. Overall, it can be concluded that the sample is not fully representative of the Dutch population. The sample has a high share of men, younger people ($\leq$ 35 years old), higher income households and people who live in a high degree of urbanity. According to literature, the target group of shared mobility users are mainly young, highly educated persons living in urban environments (Vianen, 2022). Since this group is overrepresented in the sample, it is likely that there is an overestimation of the intention to use mobility offered at a neighborhood mobility hub.

A. General findings

In the questionnaire, some statements involved the intention to use neighborhood mobility hubs. These statements reveal that the sample has a fairly positive attitude towards intending to use mobility hubs: 48.6% of the sample assumes to use a mobility hub when it is available in their neighborhood. When the walking distance from home to the hub is specified to a maximum of five minutes, even 64.5% is willing to use it. Regarding the effects of neighborhood mobility hubs on car usage and car ownership, the share is somewhat lower. 21.4% expects that their car usage will be lower when a mobility hub is present in their neighborhood. 14.8% expects to sell their second or third owned car and 8% is willing to sell their sole car when having a hub in their streets.

In order to see whether there is a relationship between the current travel behavior of users and its potential hub usage, first a closer look is needed at the current travel behavior of the sample population. In Figure 3 (Appendix A), the current travel behavior of the research sample is given, specified per trip purpose. As can be seen, regarding a visit to *friends and/or family*, the car and (electric) bicycle are a popular mode of transport. A trip towards a *sports and/or hobby* activity is often made using the (electric) bicycle (61.4%). A trip towards the supermarket is mostly done by walking, followed by the bicycle and car. The travel behavior regarding a trip to *work and/or study* is distributed more evenly among the (e-)bike (26.8%), train (33.2%) and car (31.2%). Of all travel purposes, the frequency of the trips made is highest among the latter. It is noticeable that the number of people in the sample who travel to *work and/or study* by train and bicycle is high compared to the situation in the Netherlands. Data from CBS Statline (2020) show that travel behavior to work is mainly by car (63.7%), with 13.9% traveling by train and only 6.7% by bicycle.

Below an overview is given of respondents' current travel behavior towards work and/or study and its relation with their intention to use mobility hubs in the future (Figure 2). Regarding the intention to use mobility hubs it is decided to use the question "I intend to use mobility hubs, assuming that it would be available in my neighborhood in the future", since it is the most complete behavioral intention related question.

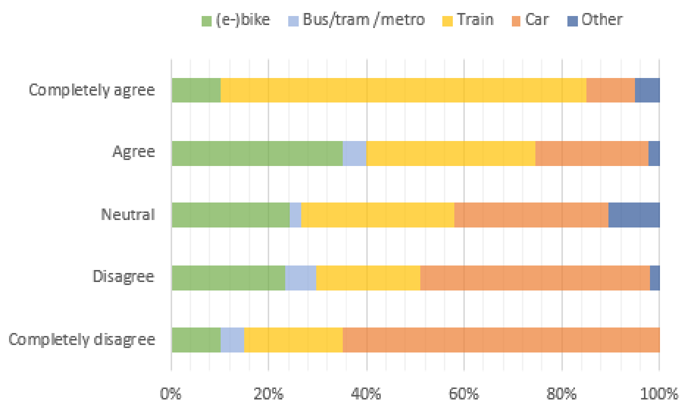

Fig. 2: Current travel behavior to travel to work and/or study and its relationship with intention to use mobility hubs

As can be seen in Figure 2, a large share of people that (completely) disagree with the question, use their car to go to *work and/or study*, indicating that they have less intention to use neighborhood mobility hubs in the future. Moreover, it can be seen that the proportion of car drivers is decreasing more and more, as a more positive image is formed about the intention to use mobility hubs. People which (completely) agree with the statement are mostly train travelers and people which use their (e-)bike to travel to *work and/or study*. From the figure it thus can be concluded that particular the travelers who choose a green and sustainable travel mode, have higher intentions of making use of shared mobility offered at mobility hubs.

B. Exploratory Factor Analysis

The first iteration gave a Kaiser-Meyer-Olkin (KMO) value of 0.885 and a significant Bartlett's Test of Sphericity (p = 0.000). This means that the sample is 'meritious' and that the data is suitable for factor analysis. The factor solution derived from the first iteration consists of 6 factors, which accounted for 64.06 percent of the variation in the data. Nonetheless, the determinant of the correlation matrix, a number of factor loadings, cross-loadings and the number of items per factor did not adhere to the set thresholds. After taking those aspects into account, it resulted in a four-dimensional structure, having a KMO of 0.874. The four factors explained a total of 60.227 percent of the variance among the items in the study. The Bartlett's Test of Sphericity proved to be significant (p=0.000) and all communalities were larger than the required value of 0.20. The determinant of the correlation matrix was <0.001 and is higher than the required value of 0.00001. In Table I, the results of the factor analysis can be seen.

TABLE I: Results Exploratory Factor Analysis

Items	1	2	3	4
Mobility hub beneficials				
PE1	0.540			
PE2	0.702			
PE3	0.515			
EE1	0.839			
EE2	0.628			
HM1	0.486			
HM2	0.481			
Facilitating conditions				
FC1		0.829		
FC2		0.781		
FC3		0.626		
Individual innovation scepticism				
II1			-0.752	
II2			-0.799	
II3			-0.702	
Social-Environmental responsibility				
SI1				0.634
SI3				0.752
SI4				0.705
EC1				0.508
EC2				0.519
EC3				0.468
EC4				0.635

The constructs performance expectancy, effort expectancy and hedonic motivation together belong to the first factor: mobility hub beneficials. The reason that these three constructs belong to one factor may have to do with the fact that all these questions are related with the advantages of mobility hubs.

The items belonging to factor 2 (facilitating conditions) and factor 3 (individual innovation) are the same as in the conceptual model. The items of factor 3 however have negative factor loadings, indicating that people which score high on this construct, have a lower degree of individual innovation. The name of the factor is therefor adjusted to individual innovation scepticism.

The constructs social influence and environmental concern combined form the last factor: Social-Environmental responsibility. This combination of constructs is somewhat surprising, but the model clearly uncovers similarities between an individuals' social influence and their concern about the environment.

C. Latent Class Cluster Analysis

A latent class cluster analysis is executed in order to find homogeneous groups in the sample that are similar based on observed characteristics and regarding to their intention to use mobility offered by neighborhood mobility hubs. First of all, the factor scores of previous section were calculated, by summing up the items belonging to each of the four factors, and dividing them by the number of items per factor. An extra factor is added to the model regarding the intention to use mobility hubs. The factor has been added to make it easier to interpret each of the classes of the LCCA.

To determine the most parsimonious model, first the measurement model needs to be estimated by choosing the number of clusters with the lowest value of BIC(LL) and AIC(LL). In Table II the BIC(LL) and AIC(LL) of the first 10 clusters can be found. The lowest value of BIC(LL) and AIC(LL) can be found at the 10th cluster, which is not desirable. A solution for this is to calculate the percentual change of BIC(LL) between clusters, in order to determine the optimal number of classes (Alonso-González et al., 2020; Van 't Veer, 2021). When the percentual change in the BIC-value shows only a small improvement in model fit, the optimal number of clusters is reached.

From on cluster 4, little improvements can be seen in percentual change of the BIC(LL) value. Consequently, for the 4,5 and 6 cluster model, the BVR values have been examined. A BVR value < 3.84 is preferred, indicating that the clusters are significantly independent of each other. Only the 6-cluster model was found to have most of the BVR values < 3.84, however the 5th and 6th cluster had a small size ($< 7\%$). As a result, the clusters are represented by very few members and interpretation is difficult. In turn, the 5-cluster model experienced a high level of covariance (BVR $>$ 3.84) between the indicators behavioral intention and mobility hub beneficials. This was solved by including a direct effect between these indicators, which relaxes the assumption of local independence (Magidson and Vermunt, 2005). The interpretation of the 5-cluster model however is limited, since cluster 1 and 2 and cluster 3 and 5 had many similarities and could not be distinguished from each other. At last, the 4-cluster model turned out to form a parsimonious model that could account for the associations between the variables. The 4-cluster model also showed a high level of covariance between *mobility hub beneficials* and *behavioral intention* and *individual innovation scepticism* and *social-environmental responsibility.* Direct effects were applied between those indicators. Only the BVR value between *social-environmental responsibility* and *mobility hub beneficials* is just non-significant.

After analyzing the percentual change in BIC values, the BVR values and its corresponding clusters, the four-cluster model is found to be the most suitable for further analysis and interpretation. The next step is to add all the covariates to the model as active covariates and remove the ones which are non-significant (Wald $<$ 3.84 and $p > 0.05$). Using backwards elimination, the insignificant covariates were removed from the model, but are still present as inactive covariates. As a last step the Entropy R-squared is determined, to check how accurately the model defines the classes, based on the observed variables. The Entropy R-squared is 0.9412, indicating that the model indicate a good classification of all individual cases into the four clusters.

The combination of the active covariates, together with the indicators, result in the final model which can be seen in Table III. The inactive covariates have been included at the bottom of the table. The latter three variables regarding the effects of a mobility hub on car usage and car ownership were not included as a moderator in the conceptual model, but are included in the final LCCA table because of its relevance to this study. Moreover, it was decided to exclude the moderator hub functionalities.

TABLE II: Number of clusters and its model fit statistics

#-Cluster	LL	BIC(LL)	AIC(LL)	Npar	Class.Err.	% change BIC(LL)
1-Cluster	-1756.80	3570.57	3533.60	10	0.0000	-
2-Cluster	-1538.70	3197.04	3119.40	21	0.0416	-10.46%
3-Cluster	-1248.36	2679.02	2560.72	32	0.0262	-16.20%
4-Cluster	-1170.72	2586.41	2427.43	43	0.0400	-3.46%
5-Cluster	-1118.94	2545.53	2345.89	54	0.0514	-1.58%
6-Cluster	-1085.23	2540.77	2300.46	65	0.0790	-0.19%
7-Cluster	-1035.52	2504.01	2223.03	76	0.0489	-1.45%
8-Cluster	-996.53	2488.72	2167.07	87	0.0537	-0.61%
9-Cluster	-970.82	2499.96	2137.64	98	0.0582	0.45%
10-Cluster	-914.23	2449.45	2046.47	109	0.0436	-2.02%

A description of each cluster can be found below.

Hub huggers - 45% of the sample

The *hub huggers* have the highest intention to use mobility hubs in the future, with the highest scores for all indicators (resp. lowest score for facilitating conditions), indicating that the intention to use neighborhood mobility hubs is high. The cluster consists of relatively young people (<35 years old) who have had a higher education (89%). The majority of the sample has a job (full-time or part-time) or is still studying. The latter probably justifies why 47% of the sample does not own a car. Of the sample, 82% has used shared transport in the past and the current travel behavior towards work and/or study is mainly done by train or (e-)bike. The possible effect of a future hub on car usage and car ownership is not the highest among all clusters, but still relatively high: 25% of the cluster members indicate that they would use their car less when a hub is present, 17% would sell their second car in the household and 9% would sell their only car.

Hub-ready impacting travelers - 25% of the sample

Members of this cluster also have relatively high indicator scores, but still need some guidance when making reservations and/or paying with their phone. Of the cluster members, 30% has a low level of education. 36% of the cluster households doesn't own a car, the remaining members own at least one car per household. Regarding travel behavior towards work and/or study: 34% uses their car, 24% goes by (e-)bike and 36% takes the train. The share of people who already have used shared transport is also quite high: 69%. Due to the presence of a mobility hub, 29% of the cluster expects to use their car less often, 20% expects to sell their second car and 11% expects to sell their only car, which is the highest among all clusters. Therefor, in comparison, this cluster will have the greatest impact in terms of car use and ownership. This may be due to the lower share of students (resp. higher incomes and age; compared to *hub huggers*) and a higher percentage of more than two cars per household. Moreover, cluster members of *hub-ready impacting travelers* live in a lower degree of urbanity.

Anti-new mobility individuals - 22% of the sample

This cluster consists of cluster members which are not (yet) willing to use hubs in the future, characterized by the lowest score for facilitating conditions meaning that the people in this cluster have the most difficulty using their mobile phone. The cluster contains all age groups, with a relative higher share (39%) of individuals older than 56. The scepticism of using new technologies paired with the higher share of older people who do not intend to change their travel behavior in the future, result in the typical anti-new mobility individual. The cluster consists of households who live on a varying level of urbanity and of which 87% has minimal one car. This also explains the high car percentage (49%) to travel to work and/or study. Of these cluster members, 44% have a high households' income of > 50.000 euros/year. The people in this cluster have little interest in changing their travel behavior, since 64% thinks that a mobility hub will not change their car usage in the future. In addition, 9% of the 'anti-new mobility individuals' think that the presence of a hub ensures that their second car is sold and 6 percent think that their only car will be sold.

Traditional car owners - 8% of the sample

The behavioral intention to use hubs as well as the mobility hub beneficials are the lowest among all clusters. This means that the members of the cluster have little urge to make use of mobility hubs in the future. The cluster consists of mainly men (82%) and car ownership is high: 92% of the households have at least one car, 72% own two cars or more. Furthermore, the majority of the cluster has no prior experience with shared mobility. Besides the car (36%), the (e-)bike is also a popular mode of travel towards work or study (36%), this may be explained by the share of people (28%) who live at their parents' house and possibly use their (e-)bike to school. The effect on car usage and ownership is very limited: 71% of the members in the cluster think that the presence of a mobility hub in their neighborhood would not affect their car usage in the future. They would still make use of their car; no person would sell their only car in the household, 4% would sell their second car.

TABLE III: 4-cluster model including its active and inactive covariates

	Hub Huggers	Hub-ready impacting travelers	Anti-new mobility individuals	Traditional car owners	Sample %
Cluster Size	45%	25%	22%	8%	
Indicators (mean)					
Mobility hub beneficials	**3.69**	3.43	2.69	2.36	
Facilitating conditions	**5.00**	4.01	3.76	4.82	
Individual innovation scepticism	1.43	1.52	**2.53**	2.38	
Social-Environmental responsibility	**3.45**	3.38	2.73	2.36	
Behavioral intention	**3.66**	3.62	2.35	1.94	
Active covariates					
Age					
18-25	**44%**	30%	8%	36%	32 %
26-35	**41%**	25%	21%	20%	31 %
36-45	7%	13%	14%	20%	11 %
46-55	7%	13%	18%	16%	11 %
56-64	2%	17%	27%	4%	11 %
65+	0%	3%	12%	4%	4 %
Education					
Primary- or secondary education	9%	7%	5%	0%	34 %
MBO, or similar	2%	**30%**	13%	24%	39 %
HBO / WO Bachelor or similar	54%	27%	43%	52%	28 %
Master's Degree	35%	36%	39%	24%	36 %
Work situation					
I work full time	55%	48%	**52%**	48%	52 %
I work part time	12%	30%	**33%**	8%	21 %
I am unemployed, looking for a job or unfit for work	0%	4%	3%	8%	2 %
I am retired	0%	3%	8%	8%	3 %
I am a student	32%	15%	5%	28%	22 %
Household income					
<€20.000	23%	17%	2%	8%	16 %
€20.000 until €30.000	6%	4%	11%	0%	6 %
€30.000 until €40.000	14%	22%	13%	19%	16 %
€40.000 until €50.000	13%	12%	14%	0%	12 %
€50.000 until €100.000	27%	29%	39%	33%	31 %
€100.000 or more	8%	6%	5%	12%	7 %
I would rather not say	10%	10%	15%	28%	12 %
Car ownership					
No car	47%	36%	13%	8%	34 %
One car	40%	37%	**46%**	**20%**	39 %
Two cars or more	13%	27%	**42%**	**72%**	28 %
Travel behavior towards work or study					
Walking	1%	0%	8%	0%	2 %
(e-)bike	**34%**	**24%**	11%	**36%**	27 %
Bus/tram /metro	4%	5%	0%	12%	4 %
Train	**40%**	**36%**	25%	12%	33 %
Car	20%	**34%**	**49%**	**36%**	31 %
Moped	1%	0%	0%	0%	0 %
Other	1%	0%	8%	4%	2 %

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Experience shared transport					
Yes	**82%**	69%	50%	20%	66 %
No	18%	31%	50%	**80%**	34 %
Inactive covariates					
Gender					
Female	43%	44%	31%	16%	38 %
Male	57%	57%	66%	84%	61 %
I'd rather not tell	0%	0%	3%	0%	1 %
Household composition					
Single	19%	11%	17%	8%	15 %
Living together, without children	36%	38%	**43%**	29%	37 %
Living together, with children	13%	27%	**32%**	28%	22 %
Single with children	1%	1%	2%	0%	1 %
With roommates / student house	28%	20%	6%	8%	20 %
With my parents	3%	3%	0%	**28%**	4 %
Urbanity					
Very strongly urban	**57%**	43%	28%	24%	44 %
Strongly urban	15%	21%	27%	36%	21 %
Moderately urban	6%	13%	9%	4%	8 %
Little urban	10%	12%	16%	16%	12 %
Non-urban	3%	5%	6%	4%	4 %
No postalcode	9%	7%	14%	16%	10 %
Do you have easy access to a car?					
Yes, whenever I want	31%	48%	69%	55%	46 %
Yes, in consultation with my hh	25%	23%	20%	36%	24 %
No, in consultation outside my hh	31%	18%	6%	4%	20 %
No, then I should rent / use shar. car	13%	12%	5%	4%	10 %
Effects of mobility hub					
The presence of a mobility hub will result in less own car usage					
Completely disagree	9%	5%	**27%**	**40%**	15 %
Disagree	13%	19%	**37%**	**31%**	21 %
Neutral	12%	19%	15%	8%	14 %
Agree	17%	**19%**	11%	8%	15 %
Completely agree	8%	**10%**	1%	0%	6 %
Not applicable to me	41%	28%	9%	12%	29 %
The presence of a mobility hub will make me sell my only car					
Completely disagree	14%	14%	32%	48%	21 %
Disagree	17%	27%	32%	28%	24 %
Neutral	10%	18%	19%	12%	14 %
Agree	8%	**8%**	6%	0%	7 %
Completely agree	1%	**3%**	0%	0%	1 %
Not applicable to me	50%	30%	11%	12%	33 %
The presence of a mobility hub will make me sell my 2nd (or 3th) car					
Completely disagree	4%	6%	19%	28%	10 %
Disagree	1%	5%	11%	16%	5 %
Neutral	4%	16%	16%	20%	11 %
Agree	10%	**12%**	6%	4%	9 %
Completely agree	7%	**8%**	3%	0%	6 %
Not applicable to me	75%	53%	44%	32%	59%

V. Conclusion and discussion

This study aimed to identify the user groups who are likely to adopt mobility offered by neighborhood mobility hubs. his was done on the basis of four sub-questions, by selecting the most appropriate technology adoption framework, distributing a survey in the Netherlands (N=298) and analyzing the results using an exploratory factor analysis and a latent class cluster analysis. From the general analysis it can be concluded that people's intention to use neighborhood mobility hubs is quite high: 48.6% of the sample intends to use a mobility hub when it is available in their neighborhood. When the walking distance from home to the hub is specified to a maximum of five minutes, even 64.5% is willing to use it. The results are less encouraging when it comes to the effects of neighborhood mobility hubs on car usage and ownership. Of the sample population, 21.4% states that they intend to use their car less often when a mobility hub is present in their neighborhood. The effect on car ownership is slightly lower: 8% expects to sell their households' sole car, while 14.8% thinks that they will sell their second or third car.

From the outcomes of the LCCA it can be concluded that two of the four clusters intent to use neighborhood mobility hubs in the future: the *hub huggers* (45% of the sample) and *hub-ready impacting travelers* (25% of the sample). The other two clusters, *anti-new mobility individuals* (22% of the sample) and *traditional car owners* (8% of the sample), are not yet ready to use neighborhood mobility hubs. The LCCA shows that in particular three indicators have a great influence in determining the intention to use hubs:

- The indicator **mobility hub beneficials** (performance expectancy, effort expectancy and hedonic motivation) appears to be highly related to the behavioral intention to use neighborhood mobility hubs. People who intend to use mobility offered at mobility hubs state that these hubs can improve their travel performance, are free from effort and fun to use.
- Neighborhood hubs are also positively associated with people who have a **social-environmental** mindset. Residents who are concerned about the environment, those who see potential in mobility hubs to contribute to a better climate and appreciate the opinion of others are more intending to use mobility hubs in the future. People who have a lower intention of using mobility hubs score low on both indicators mentioned.
- Lastly, the indicator **individual innovation scepticism** showed to be related to the intention to use hubs. The clusters that intend to use hubs, experience a low level of individual innovation scepticism, meaning that the clusters consist of people who are curious to try out new things, like to experiment with new services and usually take the lead in trying out new technologies. The opposite is visible for people in the clusters that have lower intentions to use hubs; they are more sceptic about innovations.

Besides these indicators, this research revealed that people who have prior experience with shared modes of transport have a higher intention to use hubs than people who have not. Moreover, it can be concluded that of the people who do not intend to use hubs, a large share owns at least one car. Unsurprisingly, clusters with a higher intention to use hubs have a higher share of households that do not own a car. Thirdly, the findings show that people currently travelling by (e-)bike and train show a large potential for using mobility hubs in the future. The profiles of the clusters with a higher intention to use hubs show a large share of people traveling by train or by (e-)bike, whereas clusters with a low(er) intention to use hubs have a larger percentage of people traveling by car to their work and/or study.

Regarding the effects of the different clusters on future car ownership, it can be concluded that the *hub-ready impacting travelers* have the greatest potential impact on future car use and ownership. The main difference with the *hub huggers* is that the *hub-ready impacting travelers* consist of a lower share of students (resp. higher incomes and age) and consequently a higher share of two cars (or more) per household. Moreover, cluster members of *hub-ready impacting travelers* live in a lower degree of urbanity. This makes that the potential impact on car ownership is higher among members of *hub-ready impacting travelers*. This implies that people are more inclined to sell their second (or third) car than when it is their only car. A point of attention here may be that members of the two positive clusters do not use their car as their main mode of travel, but also rely on their (e-)bike or train to reach their destination. Thus there is a risk that the offering of a mobility hub may cause an adverse effect: travelers may give up the use of PT and their (e-)bike instead of their car. Yet, this may make it more appealing for them to remain carless, which is a win-win situation. Another conclusion can be drawn for the *anti-new mobility individuals* and *traditional car owners*. These clusters are clearly not as eager in terms of reduced car usage and car ownership: neither the second (or third) car nor the households' only car have a good chance of being replaced by mobility offered at a mobility hub.

A. Limitations and recommendations

The findings of this study indicate that a successful uptake of a neighborhood mobility hub seems realistic for many people and is expected to be a potential change maker for urban mobility. This research also entails some limitations and recommendations. A limiting factor in this research is that the sample of respondents is not fully representative of the Dutch population, due to the majority of young people, males and higher educated people living in higher density areas. This may result in an overestimation of the intention to use mobility hubs. It is therefore recommended to follow up this study with a more representative sample. Moreover, this study employed 'behavioral intention' as dependent variable in the conceptual model instead of 'use behavior'. This makes this research a stated preference study, what could have resulted in an overrepresentative group of members which intend to use hubs. This is not unusual for this exploratory phase in the study into mobility hubs. However it is recommended that further studies employ a revealed preference study based on the actual usage of mobility hub users. This would also create the opportunity to add price value as an indicator. As a result, the bias will disappear and more realistic findings could occur. A small side note here is that the sample size needs to be large enough, which might be difficult given the (still) small amount of mobility hubs in the Netherlands. Regarding recommendations for practice it is advised to start developing neighborhood mobility hubs in inner-city neighborhoods. These areas contribute to a number of factors that are positively associated with the intention of using hubs, such as a maximum of five minutes walking time towards a hub, that potential hub users live in dense environments and ideally do not own a car. Moreover, when developing a mobility hub, a demographic scan of different neighborhoods is recommended which should be compared with the (cluster) demographics of this research. This might help with finding suitable neighborhoods in which mobility hubs could potentially be used. When a mobility hub is actually implemented in a neighborhood, it is advised to actively encourage its usage by bringing (media) attention and discounts. Furthermore, local governments can use push factors to encourage hub usage by residents, such as car-free zones and higher parking fees in the neighborhood.

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Appendix A: Clarification of the results

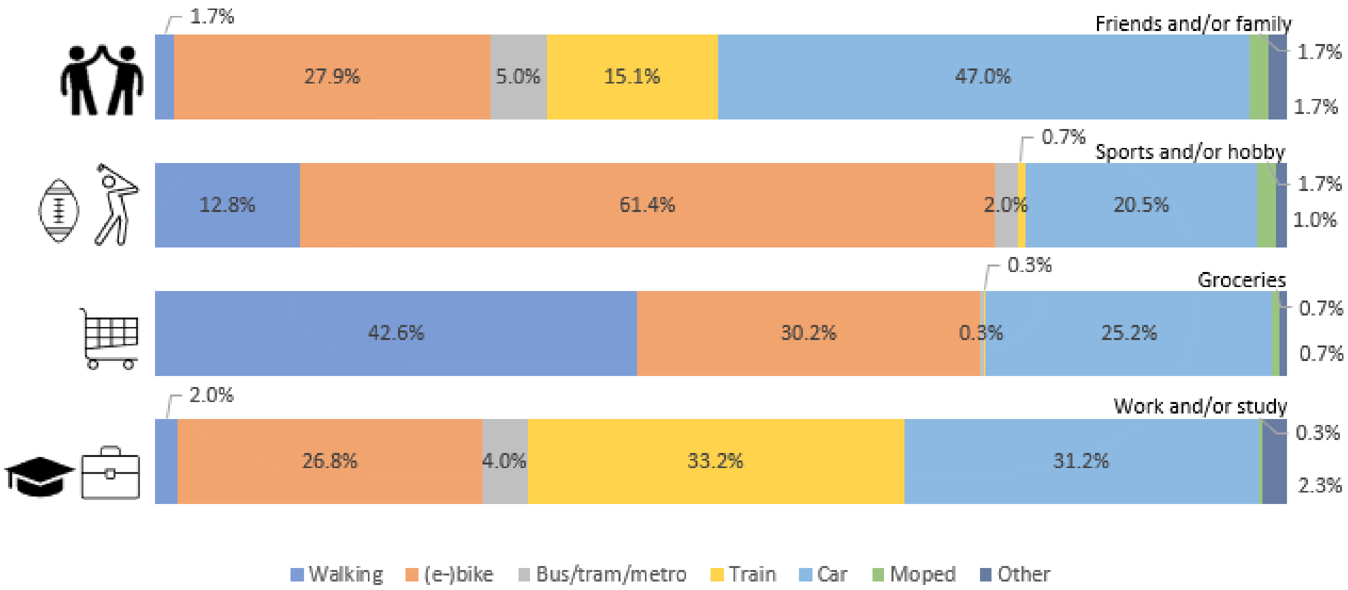


Fig. 3: Samples' current travel behavior per travel purpose

Appendix B Existing neighborhood mobility hubs in the Netherlands

More and more mobility hubs are being built in the Netherlands. Sometimes this happens through a pilot study, but more and more private companies have also discovered the mobility hub market. Below a recent overview of all (neighborhood) mobility hubs in the Netherlands is given, including the type of mobility that is offered. In Table 21 an overview is given of the companies, where the hubs are located and the type of mobility offered.

Hely
Hely is a company founded by PON and NS (Dutch Railways). Its goal is to make shared mobility more sustainable, improve the live ability in cities and offer travelers flexibility (Hely, 2021). In total, Hely operates more than 80 neighborhood mobility hubs in the Netherlands, in 13 different cities. Some hubs are open for everyone, some are only available for specific users. There are hubs for residents of residential towers and apartment complexes in major cities and for employees of companies. Using an app, users can make a reservation for different types of shared mobility: e-cars, (e-)bikes, cargo bikes and e-mopeds. Not every hub has the same type of of mobility. According to research of Hely (2021), 95% of the users make a reservation before using the shared mobility and they are willing to walk 6 minutes to a hub. In the winter, 90% of the users takes the car, in summer, more and more users (50%) opt for the (cargo) bike (Hely, 2021). More recently they added the e-moped to their fleet, there is however not yet an indication about the usage available.

eHUB
eHUB is a European project in which there is a neighborhood hub for electric shared transport at various locations in Amsterdam, Arnhem and Nijmegen (Interreg, n.d.). It's a pilot that tries to make electric shared transport available to residents of the 3 cities. There are currently 7 eHUBs located in Amsterdam, 10 in Nijmegen and 3 in Arnhem (Gemeente Amsterdam, n.d.-a; Interreg, n.d.). More hubs are planned to be added in the next two years. What distinguishes eHUBs is the bottom-up approach to realize the hub and thus close cooperation with inhabitants in the neighborhoods to determine for example the types of mobility offered. In Amsterdam, this resulted in the offering of Biròs, a small LEV which makes driving around in the dense city easier due to its compact dimensions (Gemeente Amsterdam, n.d.-a).

Mobipunt
A Mobipunt is a smaller type of neighborhood hub which mainly offers (e-)bikes, sometimes in combination with electric cars. Currently 26 hubs offer bikes and in 8 hubs the reservation of a car is possible (Mobipunt, n.d.-a). The hubs are situated in 15 different cities and villages in the provinces Noord-Holland and Zuid-Holland which are all publicly available. All hub locations are close to PT facilities, from bus stops to train stations. Moreover, a Mobipunt can function as an accessible meeting point. Services that can be offered include lockers where parcels can be delivered and a key transfer system for Airbnb or other sharing platforms (Mobipunt, n.d.-a).

MobiHUB
MobiHUB combines parking a car at a Park + Ride with offering shared mobility. All hubs are located around the center of Amsterdam, Rotterdam or Amstelveen (Mobian, n.d.). There are seven hubs in Amsterdam, one hub in Amstelveen and one hub in Rotterdam. After parking the car, users can choose to take a(n) (e-)bike or cargo bike to complete their trip to the city center. To promote the use of shared transport, users can park their car for free and only pay for the use of the (e-)bikes or cargo bikes (Mobian, n.d.).

Reis via Hub
'Reis via Hub' has implemented 55 hubs in Groningen and Drenthe in the last few years (Reisviahub, n.d.). This sounds like a lot, but not all hubs offer shared mobility. More specifically, only one of the 55 hubs offers shared transport in the form of electric bicycles. This shows that the concept of a hub is very broad and can be interpreted in different ways. The hubs all have a connection with public transport. Different services can be offered per hub, such as a charging station, WIFI, parcel lockers, bicycle lockers, toilet, kiosk, water point or bicycle shed (Reisviahub, n.d.). It is the intention that more types of shared transport will be offered in the future. According to the provinces of Groningen and Drenthe a hub should be an attractive, pleasant and practical place that users enjoy traveling through and that minimizes the 'emotional costs' of waiting and transferring (Reisviahub, n.d.). In a sense, the provinces are trying to prepare the areas in Drenthe and Groningen for other modes of mobility (Reisviahub, n.d.). Currently, people often travel direct from a to b; in the future, this is expected to go through transfer locations where people transfer between the 'appropriate' means of transport (Reisviahub, n.d.). According to the provinces of Drenthe and Groningen, hubs can play an important role to serve the future travelers well.

Table 21: Existing neighborhood mobility hubs in the Netherlands

Company	**Cities**	**Type of passenger mobility offered**
Hely	Amsterdam, Breda, Capelle ad IJssel, Delft, Rotterdam, Utrecht, the Hague, Ede, Eindhoven, Haarlem, Helmond, Leiden, Rijswijk	e-cars, (e-)bikes, cargo bikes and e-scooter
eHubs	Amsterdam, Arnhem, Nijmegen	e-cars, biro's, (e-)bikes, cargo bikes and e-scooter
Mobipunt	Nieuw-Vennep, Hillegom, Hoofddorp, Zandvoort, Haarlem, IJmuiden, Beverwijk, Alkmaar, Schagen, Middenmeer, Wieringerwerf, Anna Paulowna, Den Oever, Den Helder, 't Veld,	e-cars, bikes
MobiHUB	Amsterdam, Rotterdam, Amstelveen	(e-)bikes, cargo bikes
Reis via hub	Multiple locations in Drenthe and Groningen	bicycles

Appendix C Potential hub user characteristics, specified per mode

Below the user group characteristics specified per mode of transport is shown. In section 3.1.5, a summarize table is shown. Below the full table including references could be found.

Table 22: Potential hub user group characteristics, specified per mode

Travel mode	Potential hub user group characteristic	Source
Shared cars	Lives in a high density urban area	CROW (n.d.); Doornbos (2019); KiM (2021b); KiM (2015); Münzel et al. (2019); Prieto, Baltas, and Stan (2017)
	Younger people	Becker, Ciari, and Axhausen (2017); Burghard and Dütschke (2018); CROW (n.d.); Doornbos (2019); KiM (2021b); KiM (2015); Prieto et al. (2017)
	Elderly people without children	KiM (2015);
	Green and sustainable mindset	Münzel et al. (2019); Kerst (2019); Efthymiou, Antoniou, and Waddell (2013); van Paassen (2018); MCD (2022) Liao and Correia (2019); van der Veer et al. (2020)
	High level of education	Becker et al. (2017); Burghard and Dütschke (2018); CROW (n.d.); Doornbos (2019); KiM (2015); Prieto et al. (2017); Liao and Correia (2019); van der Veer et al. (2020)
	Higher income households	KiM (2015);
	Single households and households with younger children	Burghard and Dütschke (2018); Doornbos (2019); KiM (2015); Kerst (2019);
	Already show (multimodal) travelling with sustainable modes	Becker et al. (2017); Burghard and Dütschke (2018); CROW (n.d.); Doornbos (2019); Liao and Correia (2019) van der Veer et al. (2020)
	Low private car-ownership	Becker et al. (2017); Anable (2004); CROW (n.d.); KiM (2021b);
	Gender: mostly males	Liao and Correia (2019)
Shared bikes	Already show (multimodal) travelling with sustainable modes	Bachand-Marleau, Lee, and El-Geneidy (2012); Ma, Yuan, Van Oort, and Hoogendoorn (2020); Fishman (2015) ;
	Lives in urban areas	KiM (2021b);

Table 22 continued from previous page

Travel mode	Potential hub user group characteristic	Source
	Younger people	Bieliński and Ważna (2020); Fishman (2015); KiM (2021b); Shaheen et al. (2019)
	Middle/higher income households	Bachand-Marleau et al. (2012); Fishman (2015)
	High level of education	KiM (2021b); Fishman (2015); Shaheen et al. (2019); van Waes et al. (2018); van der Veer et al. (2020)
	White ethnicity	Fishman (2015);
	Low private bicycle-ownership	Bachand-Marleau et al. (2012)
	Gender: mostly males	Hull Grasso, Barnes, and Chavis (2020); Liao and Correia (2019)
	Low private car-ownership	Fishman (2015); Ma et al. (2020) KiM (2021b);
	Experience with MaaS	van der Veer et al. (2020)0
	Green and sustainable mindset	van der Veer et al. (2020)
Shared mopeds	Younger people;	Howe (2018); Aguilera-García, Gomez, Sobrino, and Vinagre Díaz (2021)
	Higher level of education	Aguilera-García et al. (2021); Doornbos (2019);
	Living in inner urban areas	Aguilera-García et al. (2021);
Shared scooters	Living in the city (center)	Nikiforiadis et al. (2021);
	Income	Liao and Correia (2019)
	Younger people	Nikiforiadis et al. (2021); Mitra and Hess (2021); Eccarius and Lu (2020); Bieliński and Ważna (2020);
	Already show (multimodal) travelling with sustainable modes	Eccarius and Lu (2020);
	Single households;	Mitra and Hess (2021)
	No driving license	Eccarius and Lu (2020)
	Low private car-ownership	Eccarius and Lu (2020)
	Own private (e-)scooters	Bieliński and Ważna (2020)
	Gender: mostly males	Laa and Leth (2020); Liao and Correia (2019)
	Green and sustainable mindset	Eccarius and Lu (2020); Mitra and Hess (2021);
Shared cargo bikes	Living together with children	Claasen (2020)
	Younger people	Hess and Schubert (2019)
	Reliance on the bicycle in daily lives	Hess and Schubert (2019); Dorner and Berger (2020); Becker and Rudolf (2018)
	Green and sustainable mindset	Becker and Rudolf (2018);
	Higher level of education	Dorner and Berger (2020)
	Already show (multimodal) travelling with sustainable modes	Hess and Schubert (2019)

Appendix D Survey

In this section, the survey can be found.

English (United Kingd...

Questionnaire mobility hubs

Dear participant,

This survey is part of my graduation research of the master Transport, Infrastructure and Logistics at Delft University of Technology in collaboration with engineering firm Witteveen + Bos. I want to research people's intention to use shared mobility (car sharing, bicycle sharing, shared mopeds and shared cargo bikes). These different forms of transport will be offered at a central location in the neighborhood, also known as a *mobility hub.*

Your help is very much appreciated. You must be 18 years or older and living in the Netherlands to participate in this survey. Your participation in this questionnaire is completely voluntary and anonymous and you can leave the questionnaire at any time. Your data remains confidential and is stored completely anonymized. The answers you fill in will not be traceable. The results of this survey will be used for writing and publishing my thesis.

Completing the questionnaire will take approximately 10 minutes. By completing the survey you can win a few free rides with a shared bicycle, shared scooter or shared car. If you would like to have a chance of winning, you can leave your email address at the end of the questionnaire. If you have any questions, please contact me at the email address below.

Thank you for your participation,

Ralph van der Meer
r.o.vandermeer@student.tudelft.nl

At the top of the page you can choose whether you want to complete the questionnaire in Dutch or English.

1

What is your gender? *

- ○ Female
- ○ Male
- ○ Non-binary
- ○ I would rather not say

2

What is your age? *

Please enter a number greater than or equal to 18

3

What is your household composition? *

- Single
- Living together, without children
- Living together, with children
- Single with children
- With roommates / student house
- Other

4

What is the highest degree or level of education that you have completed? *

- Primary- or secondary education
- MBO, or similar
- HBO / WO Bachelor or similar
- Master's Degree
- Other

5

Which work situation suits you best? *

- I work full time
- I work part time
- I am unemployed, looking for a job or unfit for work
- I am retired
- I am a student
- Other

6

What is the gross yearly income of your household? *

- Less than €20.000
- €20.000 until €30.000
- €30.000 until €40.000
- €40.000 until €50.000
- €50.000 until €100.000
- €100.000 or more
- I would rather not say

7

What are the first four digits of your zip code?

Do you not want to answer this for reasons of privacy? Then press next.

8

Are you in possession of a car driver's license? *

- ◯ Yes
- ◯ No

9

How many cars does your household own? *

- ◯ No car
- ◯ One car
- ◯ Two cars or more

10

Do you have easy access to a car? *

- ◯ Yes, whenever I want
- ◯ Yes, but that is in consultation with people in my household
- ◯ No, that is in consultation with people outside my household
- ◯ No, then I would have to use a shared car or rent a car

11

How are cars parked at your house? *

- ◯ On the street (paid / with parking permit)
- ◯ On the street (unpaid)
- ◯ Closed car parking lot or parking garage
- ◯ Private property
- ◯ Other

12

To get a good idea of your current travel behaviour, I would like to ask you to think about how often you normally travel.

Could you indicate for each travel purpose which means of transport you use?

*

If you use more than one means of transport to reach your destination, choose the means of transport with which you travel the most kilometres. For example: if you cycle to the train station and travel to another city by train, enter the train as the mode of transport.

	Walking	(e-)bike	Bus/tram /metro	Train	Car	Moped	Other
Work / study	◯	◯	◯	◯	◯	◯	◯
Groceries	◯	◯	◯	◯	◯	◯	◯
Sports / hobby	◯	◯	◯	◯	◯	◯	◯
Friends / family	◯	◯	◯	◯	◯	◯	◯

13

How often do you use the means of transport chosen in question 12? *

**The bicycle, e-bike, car and moped or scooter must be in your own possession.*

	4 days or more a week	1 to 3 days a week	1 to 3 days a month	Hardly or never
Work / study	◯	◯	◯	◯
Groceries	◯	◯	◯	◯
Sports / hobby	◯	◯	◯	◯
Friends / family	◯	◯	◯	◯

14

Please complete the following phrase by selecting the option you most strongly identify with: *

I prefer to reach my destination as a...

◯ Walker

◯ Cyclist

◯ Train traveler

◯ Tram / metro / bus traveler

◯ Car driver

◯ Other

The following questions are regarding the use of shared transport.

15

To what extent have you used shared transport in the past, such as a shared car (e.g. Greenwheels or MyWheels), shared bicycle (e.g. OV-fiets or Mobike) or shared moped (e.g. GO scooter, Felyx or Check)? *

	4 days or more a week	1 to 3 days a week	1 to 3 days a month	6 to 11 days a year	1 to 5 days a year	Never
Shared car	○	○	○	○	○	○
Shared moped	○	○	○	○	○	○
Shared bicycle	○	○	○	○	○	○

16

Overall, how was your experience with the shared (car/bicycle/moped)? *

- ○ Very dissatisfied
- ○ Dissatisfied
- ○ Neutral
- ○ Satisfied
- ○ Very satisfied
- ○ I have never used shared transport

17

Have you ever heard of the concept of a mobility hub before this survey started? *

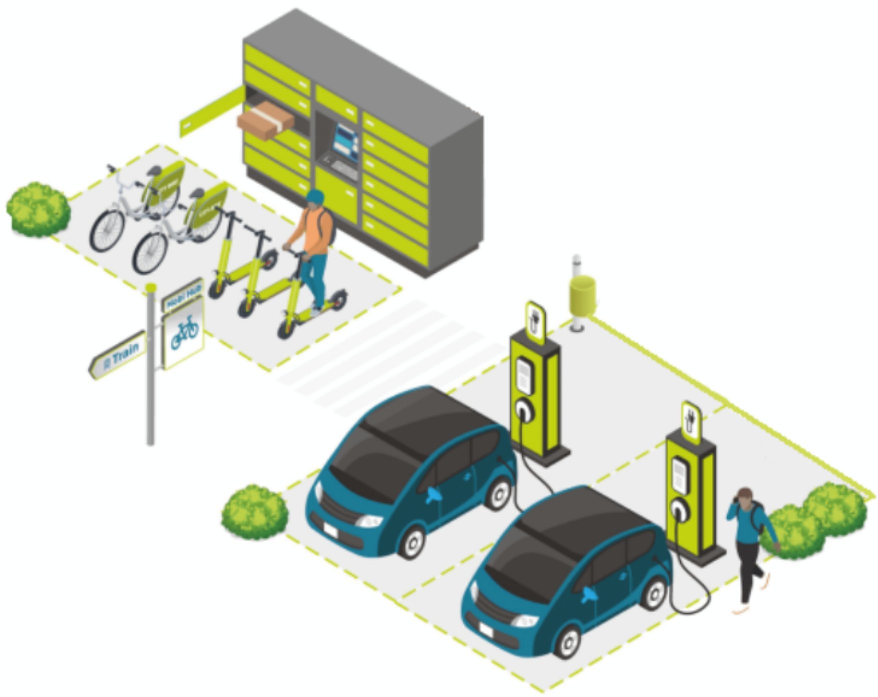
- ◯ Yes
- ◯ No

Mobility hubs

In recent years, the use of shared mobility in the Netherlands, for example shared cars, shared mopeds and shared bicycles, has grown.

For this thesis, research is done on so-called 'mobility hubs' in neighborhoods. In a mobility hub, electric shared cars, electric shared mopeds, (electric) bicycles and electric cargo bikes are offered from one central location in a residential area. You can choose which means of transport you want to use per trip and only one mobile application is required for booking, paying and opening/closing the vehicle. In addition to offering shared transport, a mobility hub can also serve as a meeting place in the neighborhood where, for example, parcel lockers can be placed. A visualization of a mobility hub is shown below.

For this mobility service, the user will have to pay a certain amount per hour. The costs differs per mode of transport. The more expensive a means of transport is to purchase, the higher the renting price is per hour. The shared vehicles are tied to fixed places: the shared vehicles must always be picked and returned to the same mobility hub.



18

After reading the explanation about mobility hubs, to what extent do you agree with the following statements? *

	Completely disagree	Disagree	Neutral	Agree	Completely agree
I think using mobility hubs will benefit me a lot	○	○	○	○	○
I intend to use mobility hubs, assuming that it would be available in my neighborhood in the future	○	○	○	○	○
I intend to use mobility hubs when the walking time to the mobility hub is less than 5 minutes	○	○	○	○	○
I intend to use mobility hubs when the walking time to the mobility hub is less than 10 minutes	○	○	○	○	○
I intend to use mobility hubs more often when additional facilities are available such as a parcel locker	○	○	○	○	○
I expect to save time travelling when using a mobility hub compared to my current way of travelling	○	○	○	○	○
I expect that travel options offered at a mobility hub will make it more convenient to reach my destination	○	○	○	○	○
It will be convenient that a mobility hub will have various means of transportation on a single location	○	○	○	○	○
I expect that using a mobility hub would be easy for me	○	○	○	○	○
I expect that making reservations would be easy for me	○	○	○	○	○

19

To what extent do you agree with the following statements? *

	Completely disagree	Disagree	Neutral	Agree	Completely agree
I don't need a private car if shared cars are available everywhere and any time	◯	◯	◯	◯	◯
I am willing to use mobility hubs if people who are important to me think that I should use it	◯	◯	◯	◯	◯
I'd rather wait for other people to try out mobility hubs before I will use them	◯	◯	◯	◯	◯
Using mobility hubs would give other people a good impression of me	◯	◯	◯	◯	◯
I am willing to use mobility hubs if the media covers it positively	◯	◯	◯	◯	◯
I am familiar with the operation of my smartphone and carry it with me when I am out	◯	◯	◯	◯	◯
I have a stable mobile network when I am travelling	◯	◯	◯	◯	◯
I am used to do payments on my smartphone	◯	◯	◯	◯	◯
I think that using a mobility hub would be fun and enjoyable	◯	◯	◯	◯	◯
I think it's very interesting to try out transport modes offered by hubs	◯	◯	◯	◯	◯

20

To what extent do you agree with the following statements?

*

	Completely disagree	Disagree	Neutral	Agree	Completely agree
I would enjoy trying out different electric powered vehicles from mobility hubs	◯	◯	◯	◯	◯
I expect to save money when using mobility hubs, compared to my current way of travelling	◯	◯	◯	◯	◯
I would be willing to pay more for shared transport from a mobility hub than I currently spend on mobility	◯	◯	◯	◯	◯
I am very concerned about the environment	◯	◯	◯	◯	◯
I am willing to reduce my CO_2 emissions to protect the environment	◯	◯	◯	◯	◯
I think mobility hubs will help reduce CO_2 emissions	◯	◯	◯	◯	◯
I expect to make use of mobility hubs in order to travel more environmentally friendly	◯	◯	◯	◯	◯
I am curious to try new things	◯	◯	◯	◯	◯
I like to experiment with new services such as mobility hubs	◯	◯	◯	◯	◯
I usually take the lead in trying new technologies, such as mobility hubs, compared to people around me	◯	◯	◯	◯	◯

21

Suppose there was a mobility hub in your neighborhood. To what extent would you consider using the following modes of transport? *

	Daily	Weekly	Monthly	Few times a year	Never
Shared electric car	◯	◯	◯	◯	◯
Shared bicycle	◯	◯	◯	◯	◯
Shared electric bicycle	◯	◯	◯	◯	◯
Shared electric moped	◯	◯	◯	◯	◯
Shared electric cargo bike	◯	◯	◯	◯	◯

22

I expect that the presence of a mobility hub in my neighborhood will result in less usage of my own car. *

- Completely disagree
- Disagree
- Neutral
- Agree
- Completely agree
- Not applicable to me

23

I expect that the presence of a mobility hub in my neighborhood will make me sell my car. *

- Completely disagree
- Disagree
- Neutral
- Agree
- Completely agree
- Not applicable to me

24

I expect that the presence of a mobility hub in my neighborhood will make me sell my second (or third) car. *

- Completely disagree
- Disagree
- Neutral
- Agree
- Completely agree
- Not applicable to me

The end!

This is the end of the questionnaire. With the button "submit" you can close and send the questionnaire. If you have any questions or comments, please contact me at r.o.vandermeer@student.tudelft.nl.

Would you like to win one of the free rides with a shared bicycle, shared moped or shared car? Enter your email address below.

25

Yes, I would like to win a free ride with a shared bicycle, shared moped or shared car!

Enter your answer

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Appendix E Approval letter ethical committee

Date 17-May-2022
Contact person [redacted]
E-mail [redacted]

Human Research Ethics Committee
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The Netherlands

Ethics Approval Application: Intention to use neighborhood mobility hubs - identifying user groups using a LCCA
Applicant: Meer, Ralph van der

Dear Ralph van der Meer,

It is a pleasure to inform you that your application mentioned above has been approved.

Please note that this approval is subject to your ensuring that the following condition is fulfilled:

1) only the digits of the postcode are collected, not the letters as well.

Good luck with your research!

Sincerely,

Appendix F Clarification of the results

In this appendix section, tables and figures have been added to clarify the results section.

Level of urbanity and intention to use mobility hubs
Below the degree of urbanity has been compared with the respondents' intention to use mobility hubs. The table shows that people living in very strongly urban or strongly urban environments have an higher intention to use hubs than people living in lower density areas.

Table 23: Level of urbanity and intention to use hubs

	Completely disagree	Disagree	Neutral	Agree	Completely agree
Very strongly urban	1%	**5%**	**11%**	**25%**	3%
Strongly urban	3%	3%	**7%**	**5%**	2%
Moderately urban	0%	1%	3%	3%	1%
Little urban	1%	3%	3%	**5%**	1%
Non-urban	0%	2%	2%	1%	0%
No postalcode	2%	2%	3%	3%	1%

Travel frequency per purpose, per mode
In section 5.2 a closer look is taken at the current travel behavior to specific trip purposes. An overview of the trip purposes is extra valuable when also encountering the trip frequency. Below the frequency of a trip towards *friends and/or family* and *work and/or study* is shown. As can be seen the frequency of a trip towards *friends and/or family* differs. The persons that cycle visit their *friends and/or family* more often than those who take the car. Not surprisingly, the frequency of trips made to *work and/or study* is high: 1 to 3 days a week or 4 days or more a week.

Table 24: Travel frequency towards family or friends, specified per mode

			Travel mode towards friends / family							Total
			Walking	(e-)bike	Bus/tram /metro	Train	Car	Moped	Other	
Frequency	4 days or more a week	Count	1	5	0	1	1	3	0	11
		% of Total	0.3%	1.7%	0.0%	0.3%	0.3%	1.0%	0.0%	3.7%
	1 to 3 days a week	Count	3	64	7	21	51	2	3	151
		% of Total	1.0%	**21.5%**	2.3%	7.0%	**17.1%**	0.7%	1.0%	50.7%
	1 to 3 days a month	Count	0	12	8	23	82	0	0	125
		% of Total	0.0%	4.0%	2.7%	7.7%	**27.5%**	0.0%	0.0%	41.9%
	Hardly or never	Count	1	2	0	0	6	0	2	11
		% of Total	0.3%	0.7%	0.0%	0.0%	2.0%	0.0%	0.7%	3.7%
Total		Count	5	83	15	45	140	5	5	298
		% of Total	1.7%	27.9%	5.0%	15.1%	47.0%	1.7%	1.7%	100.0%

Table 25: Travel frequency towards work or study, specified per mode

			Travel mode towards work / study							Total
			Walking	(e-)bike	Bus/tram /metro	Train	Car	Moped	Other	
Frequency	4 days or more a week	Count	4	59	5	35	48	1	2	154
		% of Total	1.3%	**19.8%**	1.7%	**11.7%**	**16.1%**	0.3%	0.7%	51.7%
	1 to 3 days a week	Count	1	19	6	59	40	0	2	127
		% of Total	0.3%	**6.4%**	2.0%	**19.8%**	**13.4%**	0.0%	0.7%	42.6%
	1 to 3 days a month	Count	0	1	0	1	2	0	0	4
		% of Total	0.0%	0.3%	0.0%	0.3%	**0.7%**	0.0%	0.0%	1.3%
	Hardly or never	Count	1	1	1	4	3	0	3	13
		% of Total	0.3%	0.3%	0.3%	1.3%	1.0%	0.0%	1.0%	4.4%
Total		Count	6	80	12	99	93	1	7	298
		% of Total	2.0%	26.8%	4.0%	33.2%	31.2%	0.3%	2.3%	100.0%

Intention to use hubs, statistical tests
The three items of BI were checked on whether they were statistically different. Normally, ANOVA's test is used as a starting position. However, continuous variables are needed for the analysis, which is not the case. Therefor, Friedman's test was used. Friedman's test was used to test for differences between dependent groups and is advised to use when ordinal questions are asked, which is the case for BI. The null hypothesis suggests that there are no differences between the variables ($p > 0.05$). The items BI1, BI2 and BI3 show a statistically significant difference between the willingness to use neighborhood mobility hubs (X2(2) =113.818, $p < 0.001$) (Table 26). Furthermore, a Wilcoxon test was executed as a post hoc test to establish within-subjects differences. The Wilcoxon test also showed a significant difference ($p < 0.001$) between all three items (Table 27. The intention to use hubs is higher ($p < 0.001$) when a walking time of 5 minutes is mentioned (sum = 107), than when no walking time is mentioned (BI2; sum = 26). Moreover, the intention to use hubs is lower ($p < 0.001$) for BI1 (sum = 32), in comparison with BI2 (BI2; sum = 92). Lastly, the intention to use hubs is higher ($p < 0.001$) when a walking time of 5 minutes is mentioned (sum = 142), than when no walking time is mentioned (BI1; sum = 26).

Table 26: Friedman's test

Test statistics	
N	298
Chi-Square	113.818
df	2
Asymp. Sig.	<.001

Table 27: Wilcoxon signed ranks test

	Z-value	Asymp. Sig (2-tailed)	Ranks	Value
			Negative Ranks	107
			Positive Ranks	26
			Ties	165
BI2 vs BI3	-6.098	<.001	Total	298
			Negative Ranks	32
			Positive Ranks	92
			Ties	174
BI2 vs BI1	-4.980	<.001	Total	298
			Negative Ranks	142
			Positive Ranks	26
			Ties	130
BI1 vs BI3	-8.164	<.001	Total	298

Below, the two statements regarding intention to use are shown which were deleted from the construct. In total, five statements were asked to the respondents in order to get an indication of their intention to use neighborhood mobility hubs. Since the intention to use mobility hubs will be included as a factor in the LCCA, a reliability analysis using Cronbach's Alpha was done in order to see whether the set of items are closely related as a group. It turned out that $BI4$ ("I intend to use mobility hubs when the walking distance is less than 10 minutes") and $BI5$ ("I intent to use mobility hubs more often when additional facilities are available, such as parcel lockers") resulted in a lower Cronbach's Alpha. Consequently, these statements were deleted from the construct, resulting in a reliable set of items ($\alpha = 0.88$).

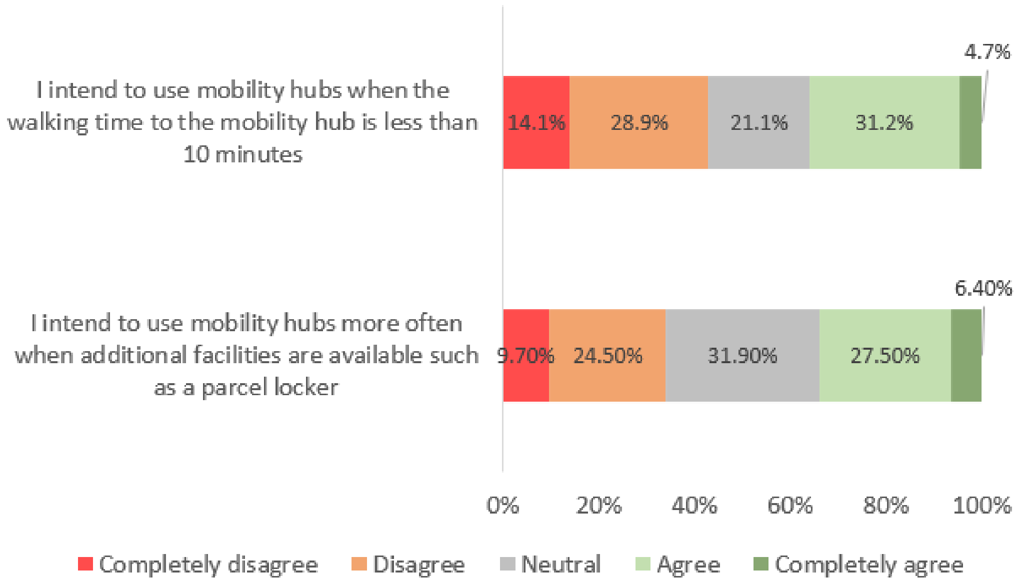

Figure 31: Intention to use neighborhood hubs, statements 4 and 5

Relationship between current travel modes and intention to use hubs
Below an overview is given of respondents' current travel behavior towards 'sports and/or hobby' and 'friends and/or family' and its relation with their intention to use mobility hubs in the future. These figures can be used in order to indicate if there exists a relation between the current travel behavior of the respondents and its intention to use mobility hubs.

Regarding sports and/or hobby, the share of car drivers is high when the respondent (completely) disagree with the statement. When being more positive about the intention to use hubs (agree and completely agree with the statement), the share of car drivers decreases drastically. Regarding *sports and/or hobby*, most people currently use the (e-)bike to reach their travel purpose and have high intentions to use neighborhood mobility in the future. For the travel purpose *friends and/or family*, it is more difficult to give an indication since a more diverse travel pattern can be seen. In this, (e-)bike, train and car travelers are potentially intending to use mobility hubs in the future.

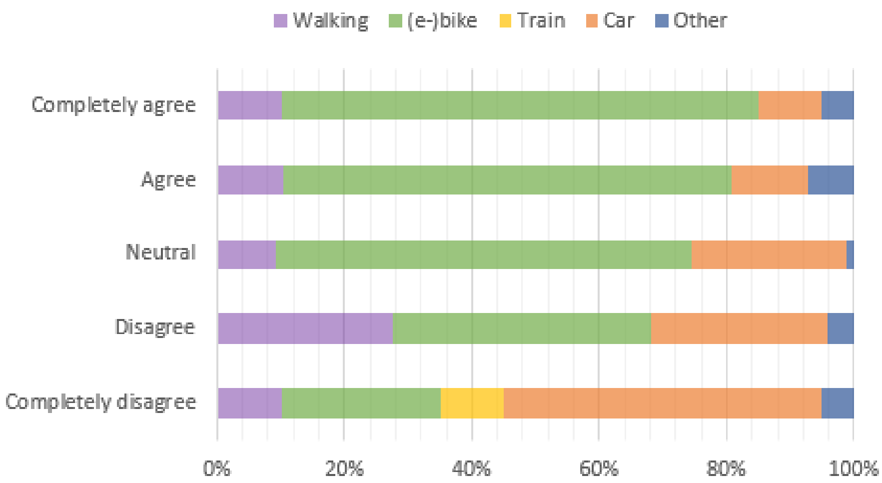

Figure 32: Current travel behavior towards sports and/or hobby and its relationship with intention to use mobility hubs

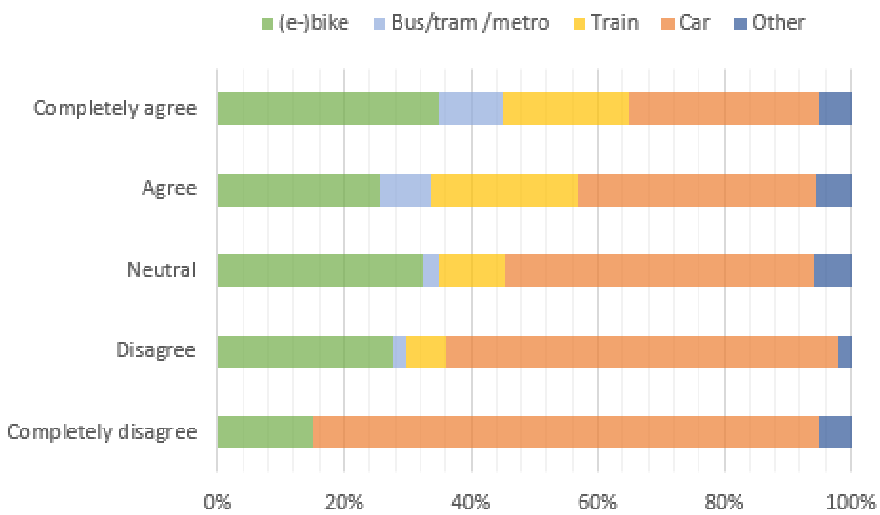

Figure 33: Current travel behavior towards friends and/or family and its relationship with intention to use mobility hubs

Intention to use shared mode, 1) per age group, 2) degree of urbanity and 3) gender
In below figures, the intention to use a specific transport mode is shown in relation to several user characteristics: age, degree of urbanity and gender. As can be seen in Figure 34, the shared car is a popular mode of travel for all age categories. The intention to use a shared moped mainly applies to the age group 18 - 25 years old and to a lesser extent on the age groups between 26 and 45 years old. The artice of Horjus (2021) indicated that shared moped users were slighly younger of age than users of shared cars and shared bikes, which is also supported by this research. Moreover, when you're over the age of 36, an e-bike is a more popular mode of transportation, especially if you only ride it a few times a year. For people aged 65 and up, the e-bike is the second most popular mode of transportation that respondents intend to use. The shared cargo bike is most popular among people aged 26 to 45. This is most likely due to the presence of young children in the household.

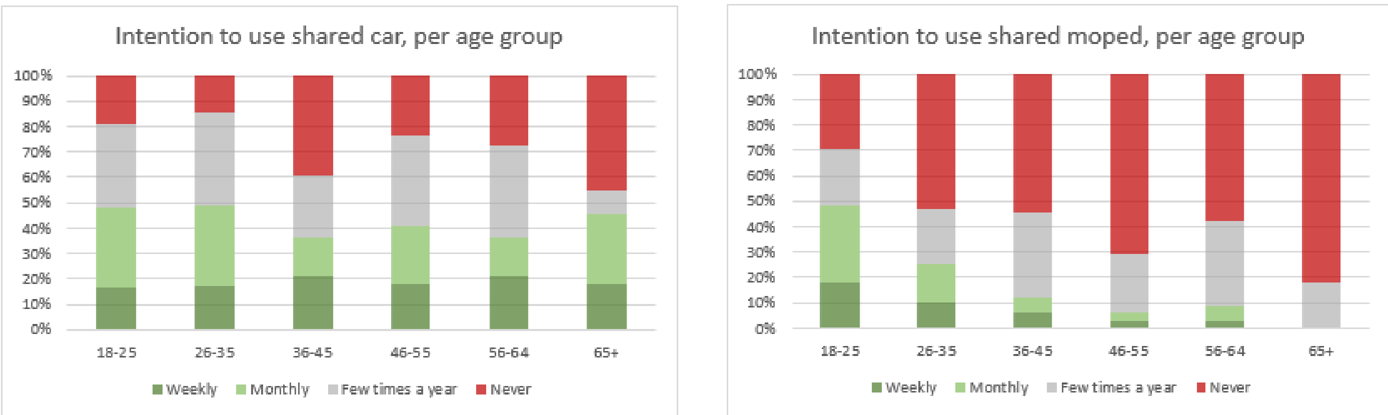

Figure 34: Intention to use shared modes, per age category

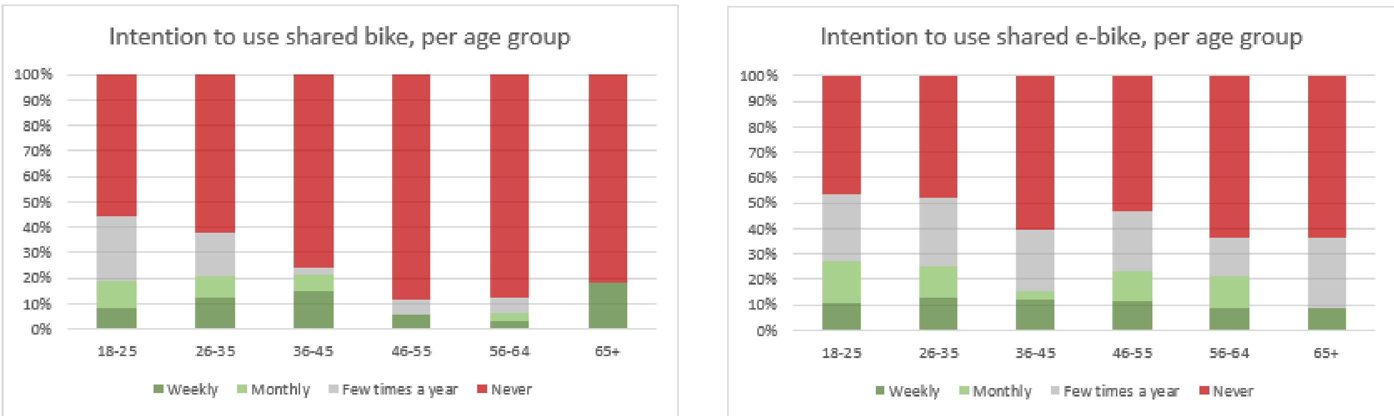

Figure 35: Intention to use shared modes, per age category

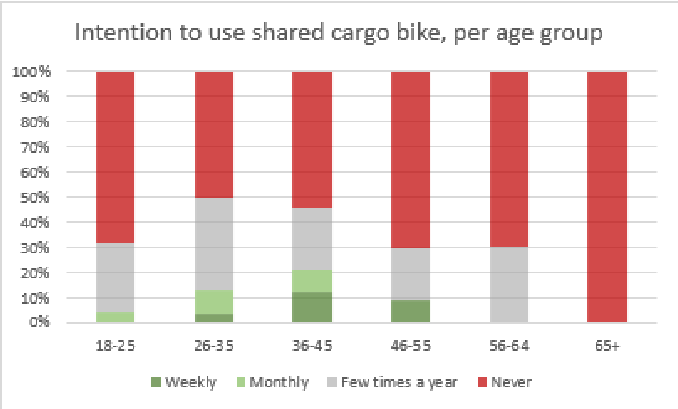

Figure 36: Intention to use shared modes, per age category

The five figures below show the intention to use the modes of transport, specified per urban degree. In general, people are less likely to use shared transportation if they live in little- or non-urban areas. However, it is notable that shared e-bikes are popular for monthly use in non-urban areas. The shared scooter, which is especially popular in very strongly urban areas, is the complete opposite.

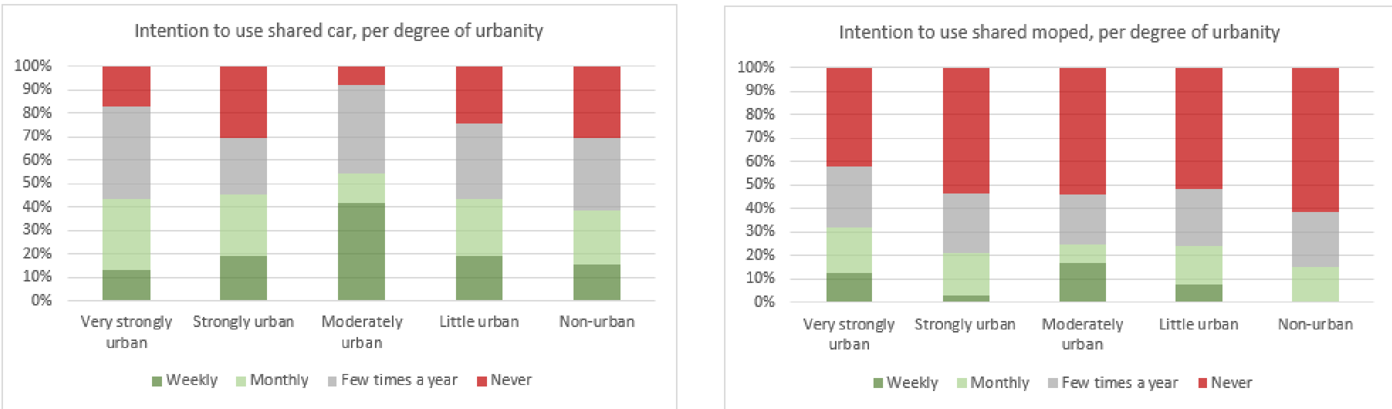

Figure 37: Intention to use shared modes, per degree of urbanity

Figure 38: Intention to use shared modes, per degree of urbanity

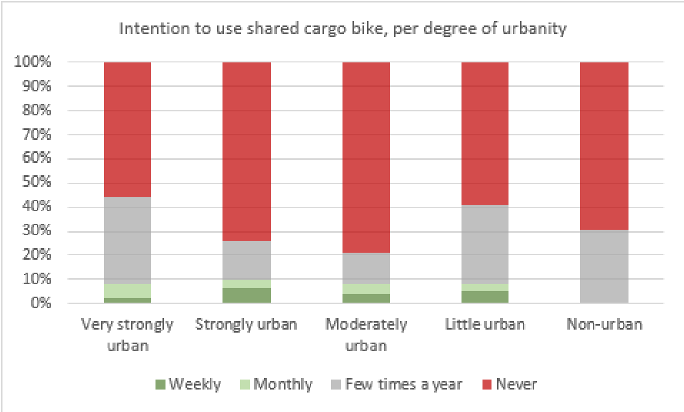

Figure 39: Intention to use shared modes, per degree of urbanity

When we look at the difference in intention between men and women and its modes of transport, It is clear that women are more likely than men to use hubs. There is little difference in potential usage for shared cars and shared mopeds, but when it comes to shared (e-)bikes and shared cargo bikes, women clearly prefer to use those modes.

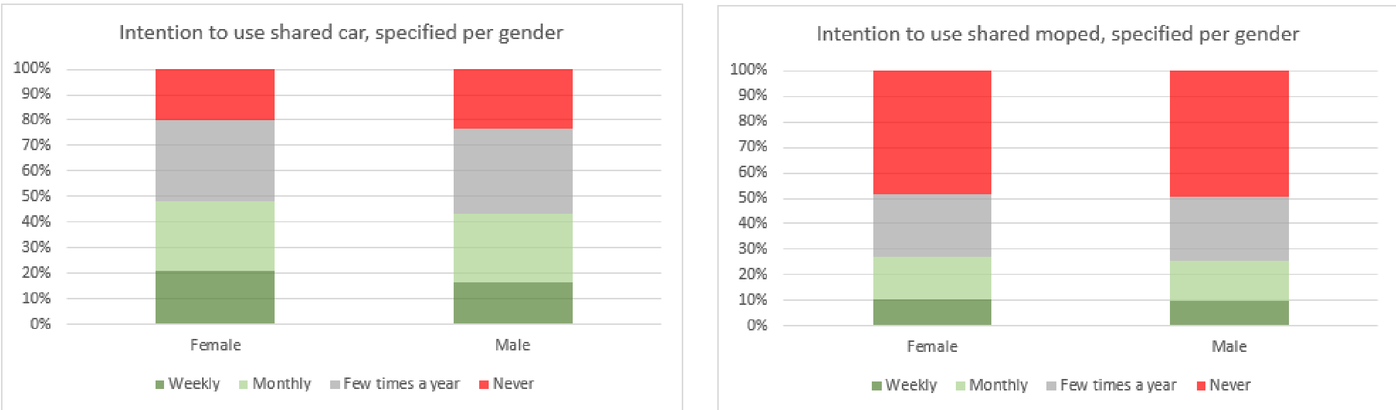

Figure 40: Intention to use shared modes, specified per gender

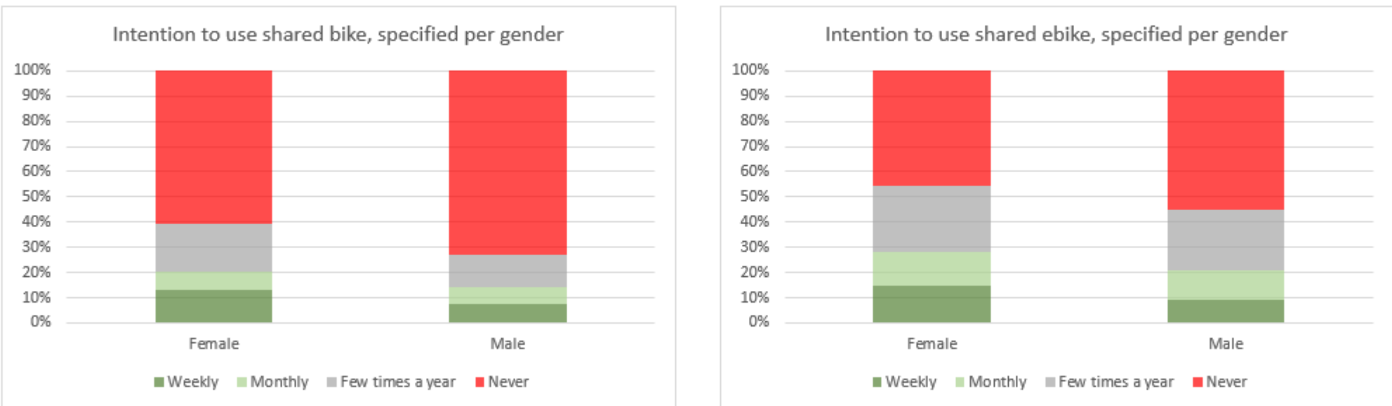

Figure 41: Intention to use shared modes, specified per gender

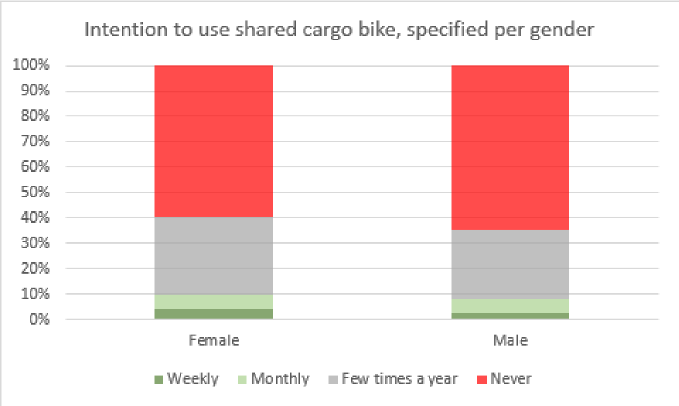

Figure 42: Intention to use shared modes, specified per gender