Potential effects of mobility hubs

Intention to use shared modes and the intention to reduce household car ownership

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Cover image
Parked cars in The Hague show the required space for privately owned cars
Meloenstraat, Vruchtenbuurt, The Hague

Preface

Before looking for a suitable subject for my thesis, I thought about the transport research areas that interest me. My previous internship research focused on topics related to the bicycle: the investigation of potential bicycle routes, traffic management measures for bicycles and the integration of the bicycle in the traffic model. I realised that I would like to focus on another topic related to either mobility management or traffic management. Arcadis offered me the opportunity to investigate the effects of mobility hubs, related to my interest in mobility management. Writing the preparation of the thesis, this soon changed to potential effect, as the mobility hubs have only been introduced through pilots.

I have learnt a lot, especially regarding setting up a survey, which was sometimes quite challenging. I am satisfied with the final survey and the results I present in this report. I am also satisfied that I have been able to contribute to the new research area of mobility hubs. This report gives insight into the results of my research into the potential effects of mobility hubs in The Hague.

I would like to thank dr. Tom Thomas and prof. dr. ing. Karst Geurs for their support and feedback during my thesis. I appreciate the valuable discussions, particularly during the set-up of the survey. The discussions helped me to improve the survey set-up, which was the most difficult part of the research for me. Special thanks to Martijn Derksen MSc of Arcadis for the opportunity to do my thesis research at Arcadis and for the discussions we had throughout the research. I would like to thank ing. Sven Mittertreiner of the Municipality of The Hague for the discussions we had about the survey and his help with the distribution of the surveys. This resulted in a relatively high number of respondents, which enabled me to do a representative analysis. I also would like to thank drs. Carla Rothuizen of the Municipality of The Hague for her help with the distribution of the letters.

Yorick Claasen
Hoorn, June 2020

Summary

Both the average household car ownership and the absolute number of private cars have increased in The Hague over the last ten years (CBS, 2019a, 2019b). Cars are parked for more than 90% of the time (KiM, 2018). This requires a considerable amount of parking space. Municipalities would like to use the parking space for other purposes due to the limited urban space. A transition from a mobility system based on car ownership towards a mobility system based on sharing may reduce the need for parking space. For instance, Nijland and van Meerkerk (2017) investigated the effect of carsharing on household car ownership among Dutch carsharing users and concluded that car ownership has reduced from 1.12 to 0.72 cars/household. However, it has not yet been investigated to what extent mobility hubs could contribute to reduce household car ownership. Mobility hubs are locations in residential areas, where shared cars, mopeds, electric bicycles and electric cargo bicycles are offered together. This research is aimed at investigating the potential effects of these mobility hubs. The intention to use mobility hubs and to relinquish a car have been investigated by conducting a survey among households with a car in two research areas in The Hague: the inner-city neighbourhoods *Geuzen- en Statenkwartier, Bomen- en Bloemenbuurt* and *Vruchtenbuurt* (N=583) and the VINEX-neighbourhoods *Ypenburg* and *Leidschenveen* (N=591). Both research areas have a high parking pressure. The investigated inner-city neighbourhoods have a larger supply of shared modes and different built environment characteristics than the investigated VINEX-neighbourhoods.

What determines the intention to use the mobility hubs?

The intention to use mobility hubs has been investigated through a stated choice experiment, focused on the last car trip from the respondent’s dwelling to a destination in The Hague. The respondent was asked to choose between:

- two mobility hubs with different characteristics and none.
- their car and one of the shared modes offered by the preferred mobility hub.

Residents of the investigated inner-city neighbourhoods are more likely to choose one of the mobility hubs, whereas residents of investigated VINEX-neighbourhoods are more likely to choose none. Thus, residents of the inner-city neighbourhoods are more positive towards the use of mobility hubs. The presence of a shared car is the most important system characteristic in the choice for a mobility hub. Subsequently, reducing the walking time with three minutes is the most important system characteristic. Increasing costs by €0.10/km for the moped and electric (cargo) bicycle are experienced as negative as a reservation obligation. People of 45 years and older are less likely to choose a mobility hub, whereas people with a positive attitude towards shared cars and sustainable transport modes are more likely to choose a mobility hub.

Residents are more likely to prefer their car rather than one of the shared modes offered by the preferred mobility hub. Besides, residents are most likely to choose the shared car among the shared modes. The other shared modes are suitable for specific situations given the large standard deviation in the utility. This implies that the added value of a mobility hub over a carsharing system is limited. However, reduced travel costs of these shared modes result in a higher chance of being preferred. All shared modes are more often preferred by inhabitants with a positive attitude towards shared cars and sustainable transport modes. This also applies to unregular trips (<1 day/week) of inhabitants of investigated VINEX-neighbourhoods, which is in accordance with previous research (KiM, 2015).

What is the potential effect of mobility hubs on household car ownership?

The potential effect of mobility hubs on household car ownership is a reduction of 15% in the investigated inner-city neighbourhoods and 11% in the investigated VINEX-neighbourhoods. It should be noted that mobility hubs must satisfy the requirements of the residents. Thus, the potential effect of mobility hubs on car ownership is limited. The shared car is the most important shared mode in a mobility hub in the decision to relinquish a car, followed by the electric bicycle. Walking time towards the mobility hub and the costs for the use of the mobility hub are the most important factors in this decision. Younger people and frequent train users are more likely to relinquish a car when providing a mobility hub. Households with more than one car are more likely to relinquish a car in the investigated VINEX-neighbourhoods, in accordance with previous research related to carsharing (Nijland, Van Meerkerk, & Hoen, 2015). This effect has not been found in the investigated inner-city neighbourhoods.

Samenvatting

Zowel het gemiddeld autobezit als het totale aantal geregistreerde auto's in Den Haag zijn in de afgelopen tien jaar toegenomen (CBS, 2019a, 2019b). Auto's worden voor meer dan 90% van de dag geparkeerd (KiM, 2018). Dit zorgt voor een aanzienlijke benodigde parkeerruimte. Gemeenten willen gezien de beperkte ruimte in de stad deze parkeerruimte voor andere doeleinden gebruiken. Een transitie van een mobiliteitssysteem gebaseerd op autobezit naar een systeem gebaseerd op delen zou het benodigde aantal parkeerplaatsen kunnen verminderen. Onder andere Nijland en van Meerkerk (2017) onderzochten het effect van autodelen op het autobezit onder Nederlandse autodeelgebruikers en concludeerden dat het autobezit daalt van 1,12 naar 0,72 auto's/huishouden. Het is echter nog niet onderzocht in hoeverre mobiliteitshubs kunnen bijdragen aan het verminderen van het autobezit. Mobiliteitshubs zijn locaties in woonwijken waar deelauto's, deelscooters, elektrische deelfietsen en deelbakfietsen gezamenlijk worden aangeboden. Dit onderzoek is gericht op het onderzoeken van de potentiële effecten van mobiliteitshubs. De intentie tot het gebruik van mobiliteitshubs en het wegdoen van een auto zijn met behulp van een enquête onderzocht onder huishoudens met auto in twee gebieden in Den Haag: de binnenstedelijke wijken *Geuzen- en Statenkwartier*, *Bomen- en Bloemenbuurt* en *Vruchtenbuurt* (N=583) en de VINEX-wijken *Ypenburg* en *Leidschenveen* (N=591). Beide gebieden hebben een hoge parkeerdruk. De binnenstedelijke wijken hebben een groter aanbod van deelvervoer en andere ruimtelijke kenmerken dan de VINEX-wijken.

Wat bepaalt de intentie tot het gebruik van mobiliteitshubs?

De intentie tot het gebruik van mobiliteitshubs is onderzocht door middel van een keuze experiment, gericht op de laatste autoverplaatsing vanaf de woning van de respondent naar een bestemming in Den Haag. Daarbij werd de respondent gevraagd om te kiezen tussen:

- Twee mobiliteitshubs met verschillende kenmerken en geen van beide;
- De eigen auto en één van de deelvervoermiddelen uit de gekozen mobiliteitshub.

Inwoners van de onderzochte binnenstedelijke wijken kiezen vaker tussen één van de twee mobiliteitshubs terwijl inwoners van de onderzochte VINEX-wijken vaker geen van beide kiezen. De binnenstedelijke wijken staan dus positiever tegenover gebruik van mobiliteitshubs. De aanwezigheid van een deelauto blijkt het belangrijkste systeemkenmerk te zijn in de keuze voor een mobiliteitshub. Het verminderen van de looptijd met 3 minuten wordt daarna als belangrijkste beoordeeld. Het verhogen van de kosten met €0,10/km voor de scooter en de elektrische (bak-)fiets wordt even negatief ervaren als een reserveringsverplichting. Mensen van 45 jaar en ouder zijn minder snel geneigd om een mobiliteitshub te kiezen, terwijl mensen met een positieve houding tegenover deelauto's en duurzame vervoermiddelen eerder een mobiliteitshub kiezen.

Inwoners geven de voorkeur aan de eigen auto boven de deelvervoermiddelen uit de gekozen mobiliteitshub. De deelauto wordt onder de deelvervoermiddelen het vaakste gekozen. De andere deelvervoermiddelen zijn geschikt voor specifieke situaties, gegeven de grote spreiding in het nut. Dit duidt erop dat de toegevoegde waarde van een mobiliteitshub ten opzichte van een autodeelsysteem beperkt is. Afnemende kosten voor deze deelvervoermiddelen zorgen er wel voor dat deze vaker worden gekozen. Alle deelvervoermiddelen worden vaker gebruikt door inwoners met een positieve houding tegenover deelauto's en duurzame vervoermiddelen. Dit geldt ook voor onregelmatige verplaatsingen (<1dag/week) van inwoners van de onderzochte VINEX-wijken in overeenstemming met voorgaand onderzoek (KiM, 2015).

Wat is het potentiële effect van mobiliteitshubs op het autobezit?

Het potentiële effect van mobiliteitshubs op het autobezit is een vermindering van 15% in de onderzochte binnenstedelijke wijken en 11% in de onderzochte VINEX-wijken. Opgemerkt moet worden dat de mobiliteitshub hierbij wel moet voldoen aan de wensen van de inwoners. Het effect van de mobiliteitshubs op het autobezit is dus beperkt. De beschikbaarheid van de elektrische deelfiets is na de deelauto het belangrijkste vervoermiddel bij de beslissing over het wegdoen van een auto. De looptijd naar de mobiliteitshub en de kosten worden bij deze beslissing als belangrijkste factoren gezien. Jongere mensen en frequente treingebruikers zijn eerder geneigd een auto weg te doen bij de komst van een mobiliteitshub. Huishoudens met meer dan één auto zijn eerder geneigd de auto weg te doen in de onderzochte VINEX-wijken, overeenkomstig met eerder onderzoek met betrekking tot autodeelsystemen (Nijland et al., 2015). Dit effect is echter niet terug te zien in de onderzochte binnenstedelijke wijken.

Extensive summary

Problem statement

Household car ownership and the absolute number of private cars have increased in The Hague over the last ten years (CBS, 2019a, 2019b). All cars need to be parked somewhere, when not being used. Since these vehicles are not used for more than 90% of the time (KiM, 2018), this requires a considerable amount of parking space. Municipalities would like to reduce household car ownership due to limited urban space and the expected urban population and employment growth.

A transition from a mobility system based on car ownership towards a mobility system based on sharing may help to reduce the level of household car ownership and the demand for parking space. The contribution of sharing to the reduction of car ownership has been investigated in the context of carsharing. For instance, Nijland and van Meerkerk (2017) concluded that car ownership has decreased from 1.12 to 0.72 cars/household among Dutch carsharing users. Furthermore, they found that carsharing users of B2C-systems were significantly more likely to reduce car ownership compared to participants of P2P-carsharing systems. The effects of shared mopeds, e-bicycles and e-cargo bicycles have not yet been investigated and are currently unknown.

The shared modes can be offered separately or combined in a mobility hub. Mobility hubs with different characteristics have recently been introduced through pilots in the Netherlands. The effects of these mobility hubs on the use of the provided shared modes and household car ownership are currently unknown. Therefore, this research aims to investigate characteristics that influence the intention to use shared modes provided by mobility hubs and the potential effect of mobility hubs on household car ownership. In this research, a mobility hub is defined as a *location in a residential area, where shared cars, mopeds, e-bicycles and e-cargo bicycles are offered together*.

Theoretical framework

The theoretical framework of this research is depicted in Figure 1. This framework is based on the Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT does not incorporate the relation between attitudes and intention to use (Venkatesh, Morris, Davis, & Davis, 2003). However, many studies, including the Theory of Planned Behaviour, show that attitudes are a determinant for the intention to use (Ajzen, 1991). Additionally, the literature review (chapter 2) shows that attitudes and socio-demographic characteristics influence the intention to use shared modes. Therefore, the relations between performance expectancy, effort expectancy, attitudes, social norm, socio-demographic characteristics, and the intention to use are investigated. Since the aim is to investigate the potential effects of mobility hubs on car ownership, the relation between intention to use and intention to reduce car ownership is also investigated. The literature review shows that attitudes, social norm, socio-demographic characteristics, and current travel behaviour affect car ownership. Therefore, these relations are investigated as well.

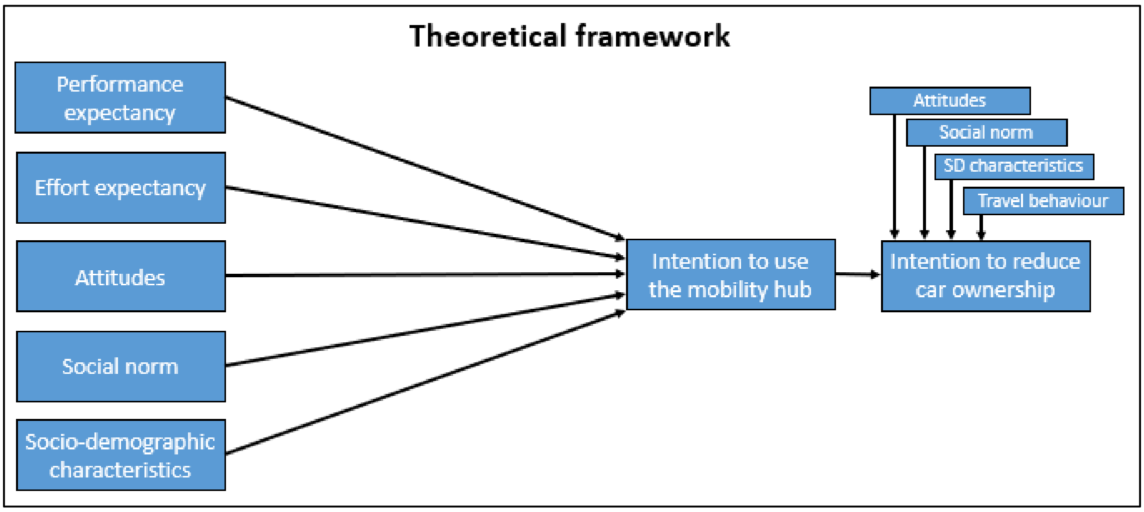

Figure 1: Theoretical framework

Existing shared mode systems

The characteristics of transport modes can usually be divided into travel costs, travel time and comfort aspects. These characteristics have been investigated for the existing shared mode systems and mobility hubs in the Netherlands in order to identify most important attributes for the choice experiments of the survey and to select the neighbourhoods to be investigated. The travel costs of existing systems are mainly based on usage fees since the registration and subscription fees are relatively low. The usage fees depend on duration only (one-way systems) or a combination of duration and distance (round-trip systems). The travel time usually consist of access, in-vehicle, and egress travel time. The access travel time relates to the access time towards the shared mode systems. Based on a GIS-analysis, it is concluded that 8% of the dwellings in The Hague are within 100 meters of a shared car, while 33% of the dwellings are within 500 meters of a shared car. The proportion of dwellings within the proximity of a shared bicycle or e-cargo bicycle is lower. Furthermore, it is concluded that the proportion of dwellings within 100, 200 and 500 meters of a shared mode differs across the neighbourhoods in The Hague. Therefore, two neighbourhoods with a different proximity to shared modes have been investigated. The comfort aspects of existing shared mode systems relate to the system characteristics, the availability of the shared modes, the booking application, the users, and the included vehicles and their properties.

Survey design

A survey is the most suitable medium to investigate the potential effects of mobility hubs since mobility hubs have currently only been introduced through pilots. Choice experiments are constructed to investigate the effects of mobility hubs on the intention to use, without the implementation of all different combinations of mobility hubs characteristics. Furthermore, an additional choice experiment related to carsharing systems was constructed to investigate to what extent the effects of mobility hubs and carsharing systems differ. The choice experiment about the carsharing systems was asked before the choice experiment about the mobility hubs to gradually build up the difficulty of the choice experiments. The choice experiment about the carsharing systems focused on the last car trip from the respondent's dwelling. The choice experiment about the mobility hubs focused on the last car trip from the respondent's dwelling to a destination in The Hague to investigate the added value of the shared moped, e-bicycle and e-cargo bicycle in a mobility hub.

Preferred carsharing systems and mobility hubs were asked to investigate the effect of individual characteristics. Based on the analysis of existing shared mode systems and mobility hubs, included characteristics were supply, costs, walking time, reservation time, users, and return location. The carsharing systems and the mobility hubs in the choice experiment were unlabelled in order to examine the different potential configurations of a single alternative (Hensher, Rose, & Greene, 2005). An opt-out option was included, since neither of the systems could be preferred in case the respondent was not able to choose due to equally (dis)advantageous characteristics. In order to investigate the effect of characteristics on the intention to use shared modes, the respondent was asked to choose between their car, or the shared car/modes provided by the preferred system.

Deciding to reduce household car ownership is a more difficult decision than deciding to use a shared mode for a specific trip. Therefore, the potential effect on household car ownership was investigated after the stated choice experiments. Furthermore, additional questions were asked to investigate the effect of socio-demographic characteristics, attitudes, and social norm on the intention to use shared modes and the intention to reduce household car ownership. Moreover, current travel behaviour, preferred transport modes and socio-demographic characteristics were used to assess the representativeness of the sample.

The survey was distributed among households with at least one car in the following research areas:

- Sample A: Geuzen- en Statenkwartier, Bomen- en Bloemenbuurt, and Vruchtenbuurt (N=583)
- Sample B: Ypenburg and Leidschenveen (N=591)

All investigated neighbourhoods have an above-average level of household car ownership and a relatively high parking pressure. The investigated inner-city neighbourhoods (sample A) have a larger supply of existing shared mode systems and are denser populated compared to the VINEX-neighbourhoods (sample B).

Results: Preferred systems

It is concluded that residents of sample A are more likely to choose a preferred carsharing system or mobility hub than residents of sample B. The availability of the shared car is the most important system characteristic of preferred mobility hubs. Residents of sample A are more sensitive for the availability of a shared car compared to residents of sample B. Increasing travel costs and walking times and a reservation obligation have a negative effect on the choice of preferred carsharing systems and mobility hubs. In contrary, sharing with known users has a positive effect. Residents of sample A are more cost-sensitive than residents of sample B. The walking time is assessed as more important in the preferred mobility hubs compared to the preferred carsharing systems. The reservation obligation is considered as more negative among residents of sample A regarding preferred carsharing systems, while this is equally negative assessed in both samples regarding preferred mobility hubs.

Trip, socio-demographic characteristics, attitudes, and social norm have a relatively large contribution on the utility of preferred systems compared to the system characteristics. A mobility hub is more often preferred for working/business purposes among residents of sample B. Furthermore, people between 45 and 65 years and people of 65 years and older are less likely to choose a preferred carsharing system or mobility hub, in accordance with previous research (e.g. KiM (2015)). People living together without children are less likely to choose a preferred mobility hub in sample A. Additionally, households with a high income (≥€41,600/year) and one-parent households are more likely to choose a preferred carsharing system in sample A. The contribution of attitudes and social norm is considerable among both systems and samples. People who agree with statements related to shared cars and sustainable transport are more likely to choose preferred carsharing systems and mobility hubs. Statement 3 (If shared cars would be available anywhere at any time, I do not need my car) has the largest contribution.

Results: Intention to use shared modes

Residents are more likely to use their car rather than one of the shared modes provided by the preferred carsharing system or mobility hub. Furthermore, residents are most likely to choose the shared car among the shared modes provided by the preferred mobility hub. It should be noted that the shared moped and e-(cargo)bicycle are only interesting alternatives to replace short distance trips, inherent to the characteristics of these modes. When considering also trips outside The Hague, the probability of choosing the shared moped or e-(cargo)bicycle is relatively small. Besides, these shared modes are only suitable for specific situations, given the high standard deviation in the error term. Altogether, this implies that the added value of mobility hubs over carsharing systems is limited. The residents of sample A are more likely to use the shared car and the other shared modes provided by mobility hubs than residents of sample B. Therefore, it is concluded that mobility hubs are potentially more successful in the investigated inner-city neighbourhoods.

A relatively small number of system characteristics have a significant effect on the intention to use shared modes since only preferred systems are considered in this analysis. Therefore, these results should be considered together with the results of preferred systems. Increasing walking times negatively affect the intention to use shared modes. Residents of sample A are more sensitive to walking times concerning the intention to use shared modes of preferred mobility hubs. In contrary, residents of sample B are more sensitive to walking times regarding the intention to use shared cars of preferred carsharing systems. Additionally, increasing travel costs negatively affect the intention to use shared modes, upon which these costs apply. Residents of sample A are less sensitive for changes in travel costs of the shared moped and e-(cargo)bicycle compared to sample B. Besides, sharing with known users has a negative impact on the intention to use shared cars of preferred mobility hubs in sample A.

Trip and socio-demographic characteristics, attitudes, and social norm affect the intention to use shared modes, similar to the results of preferred systems. The shared moped and e-bicycle are less likely to be used for longer trips (>15 km) in sample A. Additionally, the shared moped is more often used for work/business and visiting trips among residents of sample B. Visiting trips also result in a higher intention to use shared cars of preferred carsharing systems in sample B, in accordance with previous research (KiM, 2015). In contrary, shopping trips are negatively associated with the intention to use these shared cars in sample A. Furthermore, high-income households are more likely to use shared mopeds of the mobility hubs among residents of sample A. Additionally, people living together with children are more likely to use the e-cargo bicycle in sample A, inherent to the transport characteristics of the e-cargo bicycle: the ability to transport children and goods.

Attitudes and social norm have the largest impact on the intention to use shared modes of preferred systems. Previous research confirmed that attitudes and social norm are an important determinant for the intention to use (Ajzen, 1991; Dwivedi, Rana, Jeyaraj, Clement, & Williams, 2019). Residents with a positive attitude towards shared cars are positively associated with the intention to use shared modes provided by preferred systems. Residents in sample A who agree that the car gives them freedom are less likely to have the intention to use one of the shared modes. Residents in sample B are more likely to use one of the shared modes provided by preferred mobility hubs when they agree that they would choose more often for sustainable transport modes if other people would do that as well. This also applies to residents of sample A regarding shared cars of preferred carsharing systems.

Results: Potential effect on household car ownership

It is concluded that mobility hubs can potentially reduce household car ownership by 13.6% in sample A compared to 8.6% in sample B. When including the unobserved effect of not buying an extra car anymore when providing mobility hubs, the potential reduction is 15.2% in sample A and 10.9% in sample B. The results are not significantly different in both samples. Compared to a study of the actual effects of mobility hubs in Würzburg (Pfertner, 2017), the effects found in this research are relatively large. It is concluded that around 15% of the carsharing users of mobility hubs in Würzburg who had access to a private car relinquished a car due to carsharing. However, it should be noted that also people who do not have the intention to use the mobility hub are considered in the potential effect of mobility hubs on car ownership in The Hague. So, the potential effect would be larger among potential mobility hub users. The larger effect in this research may be caused by the differences in investigated neighbourhoods and the gap between revealed- and stated-preference. Moreover, the requirements of the residents considered in this research should be satisfied in terms of most important provided shared modes and beneficial factors (walking time, costs, return location, reservation time, users). The shared car is the most important offered shared mode in the decision to relinquish a car, followed by the shared e-bicycle. The shared e-bicycle is considered as more important among residents of sample B. Walking time towards the mobility hub and travel costs are the two most important factors in the decision to relinquish a car among residents of both samples. Both factors are considered as more important among residents of sample B.

It is concluded that residents who experience a higher utility in the decision of preferred mobility hubs are more likely to relinquish a car. Residents of sample A are more likely to reduce household car ownership if they experience a higher utility. Furthermore, older people and frequent car users are less likely to relinquish a car, whereas frequent train users are more likely to relinquish a car. Households with more than one car and households with a smaller annual distance with their (least used) car are more likely to get rid of their car in sample B. Higher educated people and people who frequently use the (e-)bicycle or shared modes are more likely to reduce household car ownership in sample A.

Results: Possible barriers

The possible barriers have been investigated among residents who would not (or may not) relinquish their (least used) car if a mobility hub would be provided to their preference. It is concluded that freedom and convenience of car ownership are the most mentioned barriers, followed by availability, flexibility, and independence of the private car. Additionally, the costs of the shared modes and practical issues (e.g. holidays, transport of goods and children, emergencies, needed for work) may form an obstacle for the relinquishment of a car when providing mobility hubs.

Limitations

The survey was randomly distributed among households with at least one car in the two investigated neighbourhoods. The minimum required sample size has been achieved in both samples. However, one should consider the self-selection bias since people who are less interested in the subject of the survey may be less likely to complete the survey. The results are mainly based on stated preferences because mobility hubs are currently only implemented through pilots. Stated-preference data is less reliable than revealed-preference data because they do not reflect actual choices. However, several ways were used to increase the reliability of the stated preference data such as the sequence of the questions to gradually build up the difficulty of the questions, a realistic choice context and the simplification of the attributes in the choice experiments.

The potential effect of mobility hubs on household car ownership has been investigated rather than the actual effect. The actual effect is lower than the theoretical effect given the gap between attitude and behaviour (Wilke & Bongardt, 2007). Consequently, the actual reduction in household car ownership cannot be calculated based on the results of this survey. Furthermore, the theoretical framework of this research assumes a unidirectional relation between performance expectancy, effort expectancy, attitudes, social norm, socio-demographic characteristics, and intention to use the mobility hub. Several studies show the existence of reverse-causal effects (Sussman & Gifford, 2019; Van Wee, De Vos, & Maat, 2019). However, these reverse-causal effects have not been investigated in this research. Additionally, one could argue that also other factors may affect the intention to use mobility hubs, which are not considered in the theoretical framework of this research.

Implementation in The Hague

The results presented in this research can be used for the further elaboration of the policy of the Municipality of The Hague on the implementation of mobility hubs. The results show the importance of attitudes, social norm, and socio-demographic characteristics in the decision to use the mobility hub and relinquish a car. Therefore, it is recommended to provide insight into the geographic segmentation of these characteristics to implement mobility hubs more effectively. Based on these characteristics of the neighbourhoods, the average probability of choosing specific modes can be calculated. Furthermore, it is concluded that the potential effect of mobility hubs on household car ownership is limited in the investigated neighbourhoods. Therefore, it is recommended to implement mobility hubs in combination with other car restrictive measures to achieve larger effects on car ownership. The results are specifically applicable to the investigated neighbourhoods in The Hague and cannot directly be generalized on other neighbourhoods without considering the differences in the supply of existing shared mode systems, built environment and transportation characteristics between these neighbourhoods and the investigated neighbourhoods in this research.

Recommendations

Based on the results presented in this report, the following directions for further research are defined:

- Research into preferred mobility hubs, the intention to use shared modes and the potential effect on household car ownership in other neighbourhoods in and outside The Hague.
- Research into the importance of subscription costs in return for lower variable costs in comparison with variable costs only.
- Research into the effects of mobility hubs in combination with car restrictive measures such as parking costs and parking for private vehicles further away.
- Research into the intention to use of mobility hubs in the context of other transport modes than the car to assess the economic viability of mobility hubs.
- Research into the effects on car use to provide insight into the effects of mobility hubs in terms of emissions.
- Research into the actual effects by implementing mobility hubs with preferred characteristics.

List of abbreviations

Abbr.	Meaning
ASC	Alternative specific constant
B2C	Business-to-consumer
BTM	Bus, tram, metro
CBS	Statistics Netherlands *(Dutch: Centraal Bureau voor de Statistiek)*
e-bicycle	Electric bicycle
e-cargo bicycle	Electric cargo bicycle *(Dutch: elektrische bakfiets)*
e-moped	Electric moped
e-scooter	Electric scooter *(Dutch: elektrische step)*
HTM-bicycle	Public transport bicycle owned by public transport company HTM
KiM	Netherlands Institute for Transport Policy Analysis *(Dutch: Kennisinstituut voor Mobiliteitsbeleid)*
MaaS	Mobility as a Service
ML	Mixed Logit
MNL	Multinomial Logit
MPN-data	Data from the Netherlands Mobility Panel
Mobility hub	Location in a residential area, where shared cars, mopeds, e-bicycles, and e-cargo bicycles are offered together
NS	Dutch Railways
P2P	Peer-to-peer
PT	Public transport
PT-bicycle	Public transport bicycle owned by the Dutch Railways *(Dutch: OV-fiets)*
SA	Sample A, including residents from the neighbourhoods *Geuzen- en Statenkwartier*, *Bomen- en Bloemenbuurt* and *Vruchtenbuurt* in Municipality of The Hague
SB	Sample B, including residents from the neighbourhoods *Ypenburg* and *Leidschenveen* in the Municipality of The Hague
SD	Socio-demographic
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
UL1	Urbanity level 1: very densely populated areas
UL2	Urbanity level 2: densely populated areas
UTAUT	Unified Theory of Acceptance and Use of Technology
VINEX	New built residential areas on the outskirts or proximity of cities. VINEX in this research refers to the VINEX-neighbourhoods *Ypenburg* and *Leidschenveen* in The Hague

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1 Introduction

Around 47% of the total number of trips have been made by motorized vehicles in the Netherlands in 2017 (CBS, 2017a). All these trips by motorized vehicles cause several externalities, including travel time losses, air pollution and emissions of greenhouse gasses, accidents, and noise. Besides, when the vehicle is not used, the vehicle needs to be parked somewhere. Car ownership in the Netherlands has increased from 460 vehicles per 1,000 inhabitants in 2010 towards 494 vehicles per 1,000 inhabitants in 2019 (CBS, 2019a, 2019b). 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, as shown in Figure 2 (KiM, 2018).

Despite car ownership is relatively low in cities (CBS, 2019a), urban municipalities have the policy to reduce the number of cars due to limited urban space, increasingly higher population densities and more trips being attracted (KiM, 2018; Mingardo, van Wee, & Rye, 2015). One of the ways to reduce the demand for on-street parking supply is to establish a transition from a mobility system based on car ownership towards a mobility system based on sharing. Nijland and van Meerkerk (2017) concluded that carsharing leads to a significant reduction in car ownership. This means that less parking space is required (Chen & Kockelman, 2016). Other shared mode systems can contribute to carsharing to ensure a complete mobility system based on sharing. These shared mode systems could be provided together in mobility hubs. The effects of carsharing systems are currently known. In contrary, the potential effects of providing shared modes combined in mobility hubs on the use of these shared modes and household car ownership are unknown. Therefore, this research aims at investigating the characteristics that influence the intention to use shared modes provided by mobility hubs and the potential effect of mobility hubs on household car ownership.

The literature review of chapter 2 addresses the topics that have not yet been investigated and provides a problem definition for further research. Based on that, the research design is defined, which contains the objective, research questions, and scope of this research (chapter 3). After that, the methodology is described with regard to the defined research questions (chapter 4). The results of the analysis of the existing shared mode systems and mobility hubs in the Netherlands are presented in chapter 5. Subsequently, the survey design is discussed in chapter 6. The results of this research are presented in chapter 7. Chapter 8 provides the conclusions and discussion. Finally, references and appendices are included.

Figure 2: Parked cars in Acaciastraat, The Hague

2 Literature review

This literature review discusses the car ownership problem in the Netherlands. One of the ways to reduce car ownership is to achieve a transition from a mobility system based on owning towards a mobility system based on sharing. Hence, the focus is subsequently on the different shared modes and the shared modes combined in a mobility hub. The last part of this literature review provides insight into the adoption of these shared modes and the factors that determine whether an individual chooses to use a shared mode or not. Overall, the literature review provides insight into the topics that have not yet been investigated. Based on that, the problem definition of this research has been formulated.

2.1 Car ownership

Car ownership in terms of the number of vehicles owned by 1,000 inhabitants has increased by 7.3% in the Netherlands over the last ten years (CBS, 2019a, 2019b). The same pattern cannot be seen in all four largest cities in the Netherlands. While The Hague and Rotterdam still show increases in car ownership (both 2.4%), Amsterdam and Utrecht show drops over the last ten years. Car ownership in Amsterdam has decreased by 4.4%. Moreover, Amsterdam has the lowest car ownership among the four largest cities with 272 vehicles per 1,000 inhabitants in 2019. Nevertheless, the largest decrease in car ownership over the last ten years can be seen in Utrecht with a reduction of 11% in car ownership. Although Amsterdam and Utrecht show reductions in car ownership per 1,000 inhabitants, the absolute number of private vehicles has increased in all four cities (see Figure 3). For instance, households in the capital city owned 219,000 cars in 2010, which has increased to over 235,000 private vehicles in 2019. An explanation for this could be urban population growth. All these vehicles need to be parked somewhere when not being used. Since vehicles are not used for over 90% of the time (KiM, 2018), this requires a considerable amount of required parking space at both the origin- and destination-side of the car trip.

The WHO expects that 68% of the people worldwide will live in urban areas by 2050, while this was 55% in 2018 (United Nations, 2018). In line with that, there is also an expected population growth in the urban areas in the Netherlands. PBL expects a population growth of 1% in the four largest cities in the Netherlands every year (PBL/CBS, 2016). This will lead to an even higher parking demand when car ownership trends do not change. Additionally, this population growth could lead to higher population densities when this population growth will be concentrated within the existing urban areas. This, in turn, leads to more limited space with even less room for parking lots than now. On the other hand, the number of jobs has increased by 9.4% in the four largest cities together from 2014 to 2018 (LISA, 2018). Among the four largest cities, the highest percentage increase in the number of jobs can be seen in Amsterdam (+12%). The necessary parking demand has increased as well since the share of car use in commuting trips is constantly 59% over the past years (CBS, 2017b).

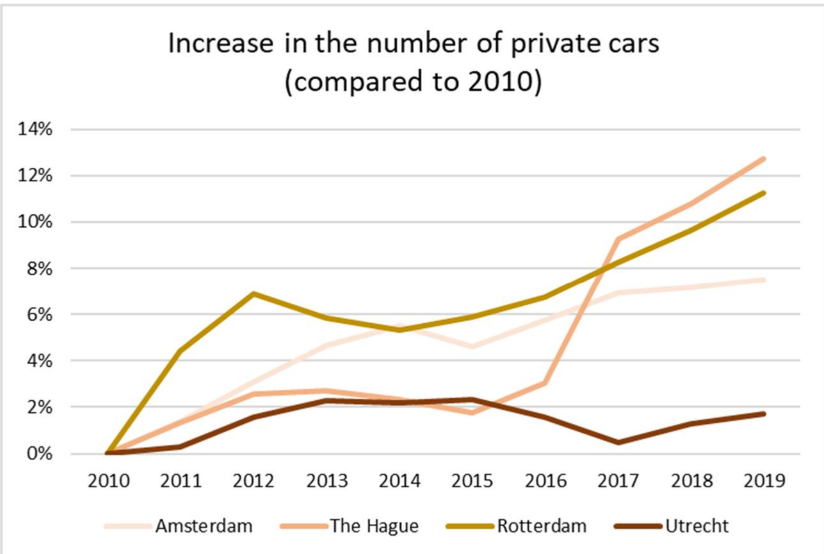

Figure 3: Increase in the number of private cars (data retrieved from CBS (2019a))

2.2 Factors affecting car ownership

As discussed in the previous section, car ownership is still increasing in the four largest cities of the Netherlands due to population and employment growth. In order to get insight into how car ownership can be reduced, it is useful to investigate the determinants of car ownership first. These influential factors can be roughly divided into the following categories:

- personal preferences and habits
- socio-demographic characteristics
- built environment characteristics
- transportation characteristics

These factors are separately discussed below. This overview covers the most important determinants of car ownership and is not exhaustive.

Personal preferences and habits

Personal preferences and habits do have a strong influence on car ownership. People in Western countries are attached to car ownership and do not consider changing their habits (KiM, 2015). Besides, many people attach symbolic and emotional value to car ownership (Steg, 2005). They see their car as a status symbol. Additionally, social norms may influence the decision to own a car. For instance, a study of Belgiawan et al. (2014) among undergraduate students concluded that the expectations of family, friends and peers are an important determinant for buying a car. Furthermore, the intention for travel behaviour decisions is the outcome of a deliberation process, including the evaluation of alternatives (Gärling & Axhausen, 2003). When habit has the most substantial influence on behaviour, there is no or less deliberation process, and the decision is (largely) based on someone´s habits. Reconsidering travel behaviour and changes in car ownership possession are most likely when changes in personal circumstances, life events, occur (Clark, Chatterjee, & Melia, 2016; Kent & Dowling, 2013). Life events that are most likely to change household car ownership are changes in household composition, driver license availability, employment status and income (Clark et al., 2016).

Socio-demographic characteristics

Socio-demographic characteristics such as gender, age, household income, education level, employment status and household composition all influence car ownership. Moreover, the influence of these factors has substantially changed in the Netherlands between 1987 and 2014 (Maltha, Kroesen, Van Wee, & van Daalen, 2017). Maltha (2016) suggested that gender has an impact on household activities and responsibilities, which affect car ownership. Car ownership in the Netherlands is higher among men and older people (CBS, 2016, 2017c). Additionally, higher household incomes and education levels go together with more car ownership (CBS, 2016; PBL, 2008). Potoglou and Kanaroglou (2008) found that medium-income households are more likely to own one car, while high-income households are more likely to own two cars. Furthermore, the higher the number of workers in a household, the higher the chance of owning two or more cars is (Potoglou & Kanaroglou, 2008). In contrary, part-time workers are less likely to own one or two cars. Oakil, Manting, and Nijland (2016) concluded that household composition is one of the most important determinants of car ownership. It appeared that households with two parents are most likely to own a car. This corresponds to findings in other literature studies. For instance, Potoglou and Kanaroglou (2008) found that couples, couples with children and extended families are more likely to own two cars.

Built environment characteristics

The built environment characteristics density, diversity, design, destination accessibility and distance to public transport all influence travel behaviour (Ewing & Cervero, 2010). All of these factors could influence car ownership. However, the unique contribution of one of these variables is difficult to measure because of multicollinearity and interaction (Cervero & Kockelman, 1997; Potoglou & Kanaroglou, 2008). For instance, highly dense urban areas often contain a lot of mixed functions, which in turn decreases distances. In general, high mixtures of land use are associated with lower levels of car ownership (Li & Zhao, 2017). Potoglou and Kanaroglou (2008) concluded that an increase in a mixture of jobs and households leads to a lower likelihood of owning two or more vehicles. In addition, households located within 500 meters from a bus stop show lower levels of car ownership (Potoglou & Kanaroglou, 2008). Besides, neighbourhoods with a higher number of bus stops are less likely to own three or more vehicles. Also, the distance to railway stations affects car ownership. Chatman (2013) showed that households living near stations are less likely to own cars. These findings indicate that the distance to public transport also affects car ownership. Urban areas can be characterized by a high density, mixed land use and a close distance to public transport. Thus, it can be concluded that the level of urbanisation is an important indicator of car ownership (Oakil et al., 2016). Car ownership is considerably lower in urban areas (Hoenjet, Jorritsma, & Waard, 2018). On the other hand, households in more rural areas are more likely to own cars (Nolan, 2010).

When considering built environment characteristics, there should also be given attention to the influence of residential self-selection on travel behaviour and specifically car ownership. Residential self-selection can be described as the tendency of people to choose residential locations based on their travel abilities, needs and preferences (Litman, 2019). Mokhtarian and Cao (2008) concluded that the residential self-selection effect is largely caused by personal attitudes and socio-demographic characteristics. For instance, it could be that low-income households without cars may choose to live in neighbourhoods with good public transport connections and hence use public transport more. Hereby, travel behaviour is not the outcome of the good public transport accessibility of the neighbourhood, but rather the preference of the household itself.

Transportation characteristics
As previously discussed, distance to public transport does influence car ownership. This indicates that the availability of other (shared) transport modes within a close distance affects the level of car ownership. In addition, generalised costs of transport modes can be expressed in travel time, travel costs and inconvenience costs (Koopmans, Groot, Warffemius, Annema, & Hoogendoorn-Lanser, 2013). Lower generalised costs of the private car may lead to more car ownership, while higher generalised costs may lead to less car ownership. For instance, Johnstone, Serret, and Bureau (2009) concluded that vehicle and fuel costs affect the level of car ownership. Besides, car restrictive measures (e.g. paid parking, parking further away, limited parking space) could significantly affect the generalised costs of the own car and may affect the level of car ownership as well. Additionally, the travel behaviour of all household members is a determinant of car ownership. An increase in the number of people working further than 6 km from their home leads to a higher likelihood to own a car (Potoglou & Kanaroglou, 2008).

In conclusion, personal preferences, habits, socio-demographic, built environment and transportation characteristics are determinants of car ownership. These characteristics should be considered when taking measures to reduce car ownership as the effect of the measures could be different depending on these characteristics.

Figure 4: One of the consequences of car ownership, Thomsonlaan, The Hague

2.3 Shared modes

In order to cope with the discussed problems concerning car ownership, municipalities take different measures. These measures should lead to a reduction in car ownership, leading to more sustainable urban areas with less room for parked cars. Municipalities can take several measures to encourage the shift from car vehicle ownership towards the use of more sustainable transport modes. The transition from a mobility system based on car ownership towards a mobility system based on (car) sharing can help to reduce car ownership (Nijland & van Meerkerk, 2017). There are different types of shared mobility systems, including carsharing, bicycle sharing and light electric vehicle sharing. This section of the literature review focuses on the characteristics of the different shared modes and their effects on car ownership.

2.3.1 Carsharing

Carsharing systems are systems that provide people the opportunity to use locally available cars temporarily on an on-demand basis (Münzel, 2020). Generally, carsharing systems can be distinguished into business-to-consumer (B2C) and peer-to-peer (P2P) carsharing. While the shared cars are owned by a carsharing company in a B2C-system, individual car owners rent out their private cars in a P2P-system (Nijland & van Meerkerk, 2017). Because cars are not owned by a company in the latter system, no further investments are needed, and the carsharing system can be easily scaled up (Meelen, Frenken, & Hobrink, 2019). This can also be seen in the number of shared private vehicles in the Netherlands. CROW (2018) concluded that the substantial increase in shared vehicles is mainly due to the increase in P2P-shared vehicles. Recently in 2017, the P2P-shared cars accounted for 86% of the total number of shared cars in the Netherlands. However, it should be noted that B2C-shared cars are used by more users than P2P-shared cars, despite the larger supply of P2P-shared cars. For instance, research of TNS NIPO (2014) showed that 20% of the carsharing users use shared cars of P2P-organisations (KiM, 2015). TNS NIPO (2014) also investigated how frequently both systems are used and concluded that both systems are mainly used for incidental trips and that B2C-vehicles are more often used in comparison with P2P-vehicles (KiM, 2015). Around 22% of the B2C-users use shared vehicles at least one time per month compared to 9% of the P2P-users.

Types of shared vehicles

The B2C-systems can be divided into one-way and round-trip carsharing systems, whereas P2P-systems are usually round-trip systems since the vehicles have to be brought back to the owner (Ballús-Armet, Shaheen, Clonts, & Weinzimmer, 2014). One-way shared vehicles can be either station-based or parked in designated areas (Münzel, Boon, Frenken, & Vaskelainen, 2018). The latter system is also called free-floating. Station-based vehicles should be parked on special designed parking lots for the concerning company, whereas free-floating vehicles can be parked on any parking place in the entire working area of the company (Stocker & Shaheen, 2017). For instance, free-floating shared vehicles of Car2Go can be parked on any (paid) parking place in Amsterdam (Municipality of Amsterdam, 2019). Contrary to one-way shared vehicles, round-trip shared vehicles should be returned to the original location of the vehicle (Stocker & Shaheen, 2017). In the case of the B2C-system, parking facilities are reserved for these vehicles. The P2P-shared vehicles should be parked on private property or any public parking place nearby.

Carsharing users

In general, carsharing users are between 25-45 years old, do belong to the above-average income groups and higher educational levels (Kopp, Gerike, & Axhausen, 2013, 2015). This is also supported by a research of TNS NIPO (2014), who investigated the characteristics of carsharing users in the Netherlands (KiM, 2015). Around 75% of the carsharing users are between 30 and 60 years old, with a strong emphasis on the age groups 30-40 years and (to a lesser extent) 40-50 years old. An explanation for the fact that carsharing people are mainly represented by the age groups 30-40 and 40-50 years has been found by Prieto, Baltas, and Stan (2017). They stated that older people are less likely to relinquish their car and use shared modes instead, because of their stronger attachment to car ownership. Additionally, around 67% of the carsharing users have a high education degree (HBO or WO). Furthermore, it can be concluded that men are more likely to use carsharing than females (Becker, Ciari, & Axhausen, 2017; Kopp et al., 2013; Prieto et al., 2017). On the other hand, TNS NIPO (2014) found that females are more likely to be potential users of carsharing systems in the Netherlands (KiM, 2015). Besides, one-person households, two-person households in the age of 50-65 years and households with young children are more likely to participate in carsharing. The first two findings regarding the household composition are in line with other literature studies, which concluded that households without children use carsharing more often (e.g. Kopp et al. (2013)). Previous research indicated that carsharing users mainly live in densely populated areas within a close distance to public transport stops (KiM, 2015; Kopp et al., 2013, 2015). These findings could be related to the fact that shared mode services are mainly provided in dense urban areas close to public transport stops because the demand for these services is in dense urban areas considerably higher compared to less dense urban areas.

Supply of shared vehicles

Meelen et al. (2019) investigated to what extent the number of shared cars (both B2C & P2P) in neighbourhoods in the Netherlands can be explained by geographical characteristics. They found that neighbourhoods with a higher level of car ownership are more likely to have zero shared vehicles. Besides, increasing the car ownership rate (number of private cars per 100 inhabitants) with one vehicle goes together with a decrease of 2.4% in B2C-vehicles and 1.0% fewer P2P-vehicles. This implies a stronger relation between car ownership and the supply of B2C-vehicles compared to P2P-vehicles. On the other hand, a lower chance of having zero shared vehicles can be found in densely populated neighbourhoods and areas with higher shares of high-educated people. Furthermore, the supply of shared vehicles is logically concentrated in neighbourhoods with regular carsharing users. Neighbourhoods with a high share of high-income households or more people aged between 25-45 years old generally have more shared vehicles. This effect is even stronger on B2C-vehicles than on P2P-vehicles.

Effects on car ownership

Nijland and van Meerkerk (2017) investigated the impact of participating in a carsharing programme among 363 Dutch carsharing users. They found that car ownership significantly decreased from 0.89 cars/household before sharing cars to 0.72 cars/household afterwards. When taking into account the unobserved effect of buying a new car if they would not start sharing cars, the total decrease is even larger (from 1.12 to 0.72 cars/household). This might be explained by life events, but has not been further investigated. In addition, the authors distinguished respondents into people participating B2C-systems, P2P-systems and both systems. By comparing the effects of these groups, they found that car ownership significantly differs between people participating in B2C- and P2P-systems. Participants of the B2C-system were significantly more likely (-0.25) to reduce car ownership than participants of the P2P-system (0.00). Even though the previous study differentiated the effects of B2C- and P2P-users, the authors did not make any distinction between the effects of one-way and round-trip B2C-systems. When considering the latter B2C-system, it appeared that round-trip B2C-carsharing has a more positive influence on car ownership than one-way B2C-carsharing (KiM, 2015).

Liao, Molin, Timmermans, and van Wee (2018) investigated the willingness of Dutch people to refrain from buying a car or dispose of a car if a carsharing system would become available nearby by a stated choice experiment. The attribute values of the own car were fixed at the properties of the respondent's car, whereas the attribute levels of the carsharing systems varied. The respondents were asked to identify whether they would refrain from buying a car or dispose of a car if the presented carsharing system would become available in their neighbourhood. By estimating latent class models, around 80% of the people are classified as ownership oriented, while around 20% of the people are classified as carsharing oriented. Respectively 72% (one-way) and 86% (round-trip) of the carsharing-oriented people, and 2% (one-way) and 3% (round-trip) of the ownership-oriented people would refrain from buying a car or dispose of a car when carsharing would become available nearby. Based on these shares, the authors concluded that around 20% of the people are likely to refrain from buying a car or dispose of a car when a suitable carsharing system becomes available nearby.

Several studies show that shared cars primarily replace the possession of a second or third car (Münzel, Piscicelli, Boon, & Frenken, 2018; Nijland et al., 2015). Nijland et al. (2015) found that 37% of the people already owning a car would buy another car if they did not join a carsharing scheme. In contrary, only 8% of the people who did not own a car before joining a carsharing system would buy a new car if they did not join.

This indicates that the shared car mainly replaces a second or third car. The reduction in the number of parking places due to the introduction of carsharing schemes cannot be found unambiguously in literature. Van Driel and Hafkamp (2015) investigated several studies and showed that a shared car replaces between 3 and 11 private vehicles. With regard to the Netherlands, the Municipality of Amsterdam (2019) found in 2006 that every carsharing vehicle replaces around 3.14 private vehicles.

2.3.2 Bicycle sharing

Bicycle sharing is usually provided at strategically located bicycle sharing stations in urban areas and primarily focuses on short one-way trips (Ricci, 2015). Besides a subscription fee, the shared bicycle is typically free of charge in the first 30 minutes in order to promote short use and maximise the number of trips being made per shared bicycle. The PT-bicycle *(Dutch: OV-fiets)* is the most used Dutch bicycle sharing service with approximately 4.2 million trips in 2018 (NS, 2019a). This is an increase of 35% in comparison with 2017. In contrary to conventional bicycle sharing systems, these bicycles should be returned at the same station. The primary goal of the PT-bicycle is to increase the number of train trips by current and new users and to expand the catchment area of train stations (Villwock-Witte & van Grol, 2015). Since almost all inhabitants of the Netherlands own a bicycle, the bicycle is already present at the access side of public transport trips (Martens, 2007). On the other hand, the share of the bicycle as an egress transport mode is relatively low. Therefore, one could expect that shared bicycle systems have the largest impact on the egress side of public transport trips. This could make public transport more interesting since the catchment area has been increased by the PT-bicycle. This results in smaller egress travel times, which makes the use of (bicycle and) public transport more likely than without a bicycle sharing system.

The effects of bicycle sharing on car ownership in the Netherlands are currently unknown (Durand, Harms, Hoogendoorn-Lanser, & Zijlstra, 2018). The direct impact of bicycle sharing on car ownership is not expected to be large since the different transport modes have different characteristics and almost all inhabitants of the Netherlands have access to a bicycle at the access side of the trip. However, the availability of bicycle sharing as an additional service to public transport could enhance the attractiveness of public transport, which may lead to a reduced need for private car ownership. Further research into the relationship between the need for car ownership and the use of bicycle sharing is needed in order to gain insight into the necessary parking demand with a specific supply of bicycle sharing (Baas, 2017).

2.3.3 Shared light electric vehicles

Besides carsharing and bicycle sharing, multiple light electric vehicles can be shared as well, such as the electric bicycle (e-bicycle), the electric cargo bicycle *(Dutch: elektrische bakfiets)*, the electric moped (e-moped) and the electric scooter (e-scooter). The provision of these shared modes could lead to a reduced need for car ownership. These light electric vehicles and their (possible) effects on car ownership are shortly discussed below.

The use of the shared e-bicycles as access or egress mode could enhance the range of public transport stations. The average distance travelled by electric bicycle is 4.8 km in comparison with 3.5 km for a regular bicycle (KiM, 2017). Kroesen (2017) concluded that the use of the e-bicycle leads to a reduction in the use of conventional bicycle and to a lesser extent the use of the car and public transport. The effects on car and public transport use are stronger than in the case of the conventional bicycle. However, there is no evidence that the e-bicycle leads to a reduction in car ownership. Kroesen (2017) found that e-bicycle ownership is no substitute for car ownership, but rather for the ownership of the conventional bicycle. The effects of e-bicycle sharing on car ownership have not yet been investigated.

In order to transport goods and/or children throughout the city, the electric cargo bicycle can be used instead of the private car. For instance, the electric cargo bicycle of Cargoroo (2019) is suitable for three children with a maximum age of approximately eight years old. The availability of shared electric cargo bicycles may lead to a reduced need for car ownership. In addition, the shared e-moped may be an alternative to private vehicles in cities, since the average speed of mopeds is comparable to private cars. For instance, the average speed of mopeds in Amsterdam is around 31 km/h, while the average speed of private cars is also considerably lower than 50 km/h (Municipality of Amsterdam, 2018a). The effects of the availability of shared electric cargo bicycles and e-mopeds on car ownership have not been found in literature and are unknown.

The shared e-scooter primarily focuses on short term use and can be returned at any location on the street (Fang, Agrawal, Steele, Hunter, & Hooper, 2018). A pilot in Portland (USA) showed that 6% of the users got rid of their private car and 16% considered this (PBOT, 2018). On the other hand, the e-scooter has negative impacts such as increases in injuries among e-scooter drivers (Mayhew & Bergin, 2019). Parked e-scooters may also block pedestrian access on walkways (Fang et al., 2018) and e-scooters users make illegally use of the sidewalk (PBOT, 2018). Although shared e-scooters systems have been introduced in several American, Asian and European cities (Mayhew & Bergin, 2019), there is no existing shared electric scooter system in the Netherlands due to strict legislation. The e-scooter can only get permission to the public road when designated by the minister as a special moped (Rijksoverheid, 2019).

2.4 Mobility hubs

Shared modes can be offered separately or combined in a mobility hub. There are several definitions of mobility hubs that differ in their characteristics, such as the size, type of location and type of offer. According to Aono (2019), mobility hubs offer sustainable and shared mobility services, which are often clustered around major transit stations. The study of Miramontes, Pfertner, Rayaprolu, Schreiner, and Wulfhorst (2017) emphasises that a mobility hub connects public transport and shared mobility services. These mobility hubs can be applied on a neighbourhood level across cities to promote multimodal transport on local levels (Share North, 2017). According to SANDAG (2019), these mobility hubs can be found at places where there is a concentration of employment, housing, shopping and/or recreation. Based on the neighbourhood specific characteristics and needs, the mobility hub can be tailored. All these definitions have in common that it is about a specific location, often well served by public transport, which provides sustainable and shared transport services. However, these definitions do not include information about the offered shared modes. Interreg NWE (2019) uses a more specific definition. Mobility hubs are defined as "on-street locations that bring together e-bicycles, e-cargo bicycles, e-scooters and/or e-cars" (Interreg NWE, 2019). Based on this definition, a mobility hub in this research has been defined as a *location in a residential area, where shared cars, mopeds, e-bicycles and e-cargo bicycles are offered together*.

The primary objective of mobility hubs is aimed at the reduction of car ownership, car use and car use-related emissions (Aono, 2019; Interreg NWE, 2019; SANDAG, 2019). By providing mobility hubs, the inhabitant can be mobile without owning a private car (Miramontes et al., 2017). This, in turn, leads to less required parking supply on-street and more efficiently use of the required space (shareNL, 2018). The mobility hub could also increase equity among elderly, disabled people, and low-income groups. For instance, mobility hubs could provide adaptive shared bicycles or scooters and alternative payment options for low-income groups (SANDAG, 2019). In addition, it may lead to more connection among people living in the same neighbourhood due to sharing (shareNL, 2018).

Mobility hubs can be applied in existing and new residential areas. Although characteristics may be the same, the effects may differ. While inhabitants of existing residential areas are used to their regular travel options (and the ownership of a car), people moving to new residential areas with mobility hubs and a low parking supply are made aware of the innovative concept. This, in turn, can attract people that are willing to use the shared modes provided by these mobility hubs. In such a case, there is a self-selection bias, which may lead to more positive effects than in the case of existing residential areas. Therefore, the different types of mobility hubs are separately discussed for existing and new residential areas.

Mobility hubs in existing residential areas

Mobility hubs have recently been introduced or are planned to be introduced through pilots in several cities in the Netherlands. For instance, the Municipality of Utrecht has planned to introduce mobility hubs in the parking garage Grifthoek in the middle of three existing residential areas Vogelenbuurt, Wittevrouwen and the central part of the city (shareNL, 2018). These mobility hubs consist of shared (electric) B2C-, P2P-vehicles and cargo bicycles. Besides, the company Hely (2019) has introduced mobility hubs in Amsterdam, Delft, The

Hague, Haarlem, Rotterdam and Utrecht. These mobility hubs consist of shared (e-)bicycles, e-mopeds, cargo bicycles and (electric) cars. Furthermore, around 30 electric mobility hubs will be developed in Amsterdam, Arnhem and Nijmegen as part of a European pilot (Interreg NWE, 2019). Four types of e-hubs will be built, which differ in size, location and offered shared modes. Since the mobility hubs discussed above have recently been introduced through pilots or are still only planned, the effects are currently unknown.

Mobility hubs in existing residential areas have been introduced in several German cities as well. Literature studies provide insight into the characteristics of these mobility hubs and effects in Munich and Würzburg. The mobility hub in Munich is located in a dense mixed-use area with around 18,000 people living within 10 minutes walking time (Villarreal, 2018). The mobility hub combines the existing shared services of the city and is well served by public transport. In full possession, it consists of five free-floating shared cars, one station-based shared car and twenty shared bicycles. A survey of Miramontes et al. (2017) among free-floating car users and bicycle sharing users showed that around 75% of the respondents think that car ownership becomes unnecessary with the mobility hub. A study of Team Red (2015) showed that 11.6% of the carsharing users relinquished a car, 39% of the people decided not to buy a car, and 27.2% of the respondents with more than one car planned to give up at least one car in the next year. Around 49% of all these respondents indicated that carsharing was a strong or very strong influencing factor on the car ownership related decisions. Unfortunately, the study does not provide insight into the effects of bicycle sharing on car ownership.

While the mobility hub in Munich is situated at one location, the mobility hubs in Würzburg are more spread over the city (Villarreal, 2018). The locations of the mobility hubs in Würzburg were selected based on a highly dense and mixed-use urban area, connection to the road network, high on-street parking demand and distribution of the stations over the city (Pfertner, 2017). Pfertner (2017) conducted a survey and compared the change in household car ownership between non-users and users of carsharing and bicycle sharing in Würzburg over a year. Carsharing and bicycle sharing users showed reductions in car ownership, whereas the non-users showed an increase in car ownership. While 5% of the non-users living in Würzburg reduced the number of cars in their household, 15% of the carsharing users got rid of their car. Among these carsharing users, 46% indicated that carsharing had a large or very large influence on this decision. In the meantime, 8% of the non-users and 4% of the carsharing users increased the number of cars. In the case of bicycle sharing users, 21% of the users reduced the number of cars, while none of the respondents increased the number of cars in their household. It should be noted that only fourteen bicycle sharing users were questioned. The availability of bicycle sharing was in one of these three cases the deciding factor to reduce the number of cars. This indicates that it is not very likely that the availability of bicycle sharing largely influences car ownership in Würzburg.

Furthermore, the City of Oakland developed a tool to identify suitable locations for mobility hubs based on priorities with regard to low automobility, disadvantaged population groups, resiliency, future growth potential, new service viability, high transportation connectivity and high land-use intensity (City of Oakland, 2015). The preferred scenario of the municipality was based on their policy goals and successful use of mobility hubs and took primarily into account all factors except high transportation connectivity and land-use intensity. The locations that scored high on all other factors were assessed to be potential locations of mobility hubs. Subsequently, most potential locations were determined based on consecutively the maximum distance between two hubs, proximity to existing infrastructure and areas with a high residential or job density. After that, the provided shared mode(s) were selected for each potential mobility hub location, considering the slope of streets, proximity to transportation infrastructure and services, and the socioeconomic characteristics of the inhabitants. Potential mobility hub locations in areas with high slopes more often focused on e-bicycle and scooter sharing, rather than bicycle sharing. Mobility hubs located near major transportation stations and in high-density areas were selected as mobility hubs for one-way carsharing. In addition, bicycle sharing was excluded from potential mobility hub locations far away from other destinations. E-bicycle sharing and scooter sharing were mainly provided in areas with high-income levels, since these modes are relatively expensive compared to bicycle sharing.

In contrary to the mobility hubs that have been introduced in the Netherlands, the effects of the mobility hubs on car ownership are known in Munich and Würzburg. However, the effects of the individual characteristics of these mobility hubs on the use of the provided shared modes are unknown. Additionally, the City of Oakland provided a tool to identify potential locations for shared modes but did not consider other characteristics of the mobility hub and the effect on car ownership.

Mobility hubs in new residential areas

Mobility hubs are also being introduced in new residential areas, often in combination with limited parking supply. The mobility hubs will be introduced in combination with an innovative spatial and parking concept in the new residential area Merwede in Utrecht, as part of a whole innovative mobility system (Goudappel Coffeng, 2018). The shared mobility services will be provided on several spots in the neighbourhood. For instance, shared cars will be provided in parking garages, so inhabitants will have access to shared vehicles in the proximity of their house. However, there has not been made any clarification of the specific locations and characteristics of the mobility hubs. In addition to the mobility hub, pre-conditions are defined in order to achieve a successful innovative mobility system. These requirements contain a maximum parking standard of 0.3 parking lots/household, regulated parking in adjacent neighbourhoods, the improvement of public transport and walking/bicycle connections. Similar requirements are provided by the municipality of Amsterdam in case of the Sluisbuurt and Strandeiland (Derksen, 2019). The possibilities for these mobility hubs have been investigated for these new residential areas (Municipality of Amsterdam, 2018b). Shared electric vehicles and shared electric (cargo) bicycles are planned to be provided in both a central hub and smaller mini hubs, situated in the proximity of public transport stops. Overall, the effects of mobility hubs in new neighbourhoods on car ownership are currently unknown because the effects have not been measured or the mobility hubs have not yet been implemented.

2.5 MaaS

As discussed in the previous section, different types of shared transport modes are provided in mobility hubs. All these (shared) transport modes can be offered together by the use of one single mobility package Mobility as a Service (MaaS). Hietanen (2014) defined MaaS as a mobility distribution model, which satisfies the major transportation needs of the users by offering mobility services through a single interface (Jittrapirom et al., 2017). By providing integrated multimodal transport services through one application, it offers an alternative for car ownership and non-integrated transport services (Arthur D. Little, 2018; Sochor, Arby, Karlsson, & Sarasini, 2018). Based on the different defined definitions of MaaS, Jittrapirom et al. (2017) summarised MaaS in nine core characteristics: integration of transport modes, tariff option, single platform, multiple stakeholders, use of technology, demand-oriented, registration requirement, personalisation and customisation. However, the current MaaS applications do not all include all these characteristics.

There are currently different types of MaaS, which can be distinguished according to their level of integration (Sochor et al., 2018). These levels of integration are:

- Level 0: No integration
- Level 1: Integration of information
- Level 2: Integration of booking and payment
- Level 3: Integration of the service offered
- Level 4: Integration of societal goals

As level 1 supports the decision-making process for finding the best trip, level 2 also integrates the booking and payment of the provided services (Sochor et al., 2018). While the first two levels focus on offering services for trips, level 3 includes the integration of the whole service. It offers all household needs in terms of mobility, which makes it an interesting alternative for car ownership (Sochor et al., 2018). Level 4 focuses on both the fulfilments of the customer and municipality by including incentives, e.g. choosing more sustainable transport modes to achieve objectives of the municipality, such as reduced car ownership.

Potential users

Zijlstra, Durand, Hoogendoorn-Lanser, and Harms (2019) investigated Dutch population groups that are relatively most likely to be potential users of MaaS. They found that the most relevant factors in determining the chance of being a potential user of MaaS are age category, frequency of public transport use, the number of aeroplane trips for personal purposes, educational level and concerns about the environment. Higher educated young people, who frequently use public transport, are most likely to be potential users of MaaS (Zijlstra et al., 2019). On the other hand, older adults with a low trip frequency, poor health, low income and educational level are found to be the least likely group to use MaaS. The relation between the frequency of public transport use and potential use of MaaS is also found in other literature studies. For instance, a study of Ho, Hensher, Mulley, and Wong (2017) showed that frequent car users, who make less frequent trips with public transport, are also among the least likely groups to use MaaS. Furthermore, being not familiar with using non-privately owned multiple modes can form an obstacle for using MaaS (Durand et al., 2018). As previously mentioned in the core characteristics, MaaS is a single digital platform which makes use of technology, such as applications on mobile phones and websites (Jittrapirom et al., 2017). Thus, potential users should be able to deal with these applications or websites, which requires ICT skills (Durand et al., 2018).

2.6 Adoption of shared modes

The success of the implementation of a mobility hub depends on the adoption of the offered shared modes. Rogers (2003) defined innovation as an idea, practice or object that is perceived as new by an individual. Straub (2009) emphasises that innovation does not have to be objectively new since it is about the perception of an individual regarding innovation. Recently, shared modes have been introduced on a larger scale and have been offered together in mobility hubs. Therefore, the concept of shared modes and mobility hubs can be classified as an innovation. The individuals and the choices they make to accept or reject the innovation are being examined by the adoption theory (Straub, 2009).

TAM

Davis (1989) introduced the Technology Acceptance Model (TAM, see Figure 5). The TAM is based on the Theory of Reasoned Action (TRA) and examines the relationship between attitudes and actions, mediated by intention (Ajzen, 1996; Straub, 2009). The perceived usefulness and perceived ease of use are assumed to be fundamental determinants of user acceptance (Davis, 1989). Thus, the TAM assumes that the behavioural intention can be explained by these two factors, which in turn are affected by external variables (Venkatesh, 2000). While perceived usefulness refers to "the degree to which a person believes that using a particular system would enhance his/her job performance", perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). Moreover, the perceived ease of use also influences the perceived usefulness (Benbasat & Barki, 2007). Venkatesh (2000) noted that the easier a system could be used, the more useful it can be. Subsequently, the behavioural intention to use a system is found to be the most important determinant for the actual behaviour.

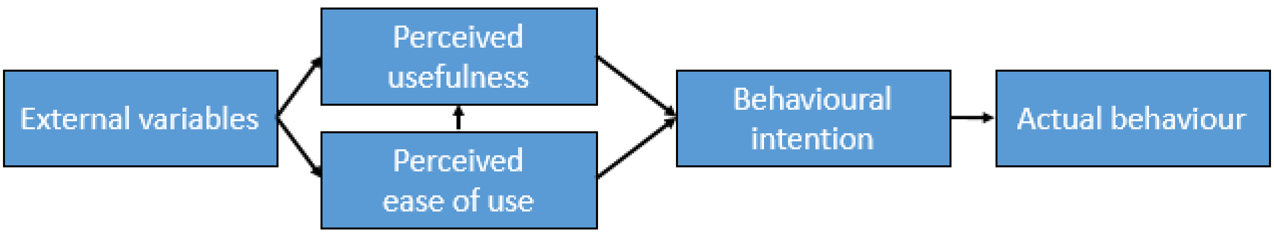

Figure 5: Technology Acceptance Model (adapted from Davis (1989))

Although the TAM is appreciated because of their simplicity, other adoption theories have been developed afterwards to incorporate more determinants of behavioural intention (Straub, 2009).

UTAUT

The most common extension of the TAM is the Unified Theory of Acceptance and Use of Technology (UTAUT), which incorporates four user acceptance criteria and four moderators for behavioural intention (Kaur &

Rampersad, 2018; Straub, 2009). The user acceptance criteria include performance and effort expectancy, social influence, and facilitating conditions, whereas the four moderators are gender, age, experience, and voluntariness of change (see Figure 6). The first two user acceptance criteria are similar to the perceived usefulness and perceived ease of use of the TAM. Social influence refers to “the degree to which an individual perceives that important others believe he or she should use the new system”, whereas facilitating conditions is defined as “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system” (Venkatesh et al., 2003). Benbasat and Barki (2007) noted that adding these last two user acceptance criteria leads to a model that is quite similar to the Theory of Planned Behaviour because these criteria are similar to subjective norms and perceived behavioural control.

The performance and effort expectancy of the UTAUT are further discussed below in the case of shared modes. As discussed, these two factors can be found in both adoption theory models. Social influence is only present in the UTAUT model, but one can argue that social influence and facilitating conditions have an impact on the perceived usefulness or perceived ease of use as external variables. In this case, these variables are also present in the TAM.

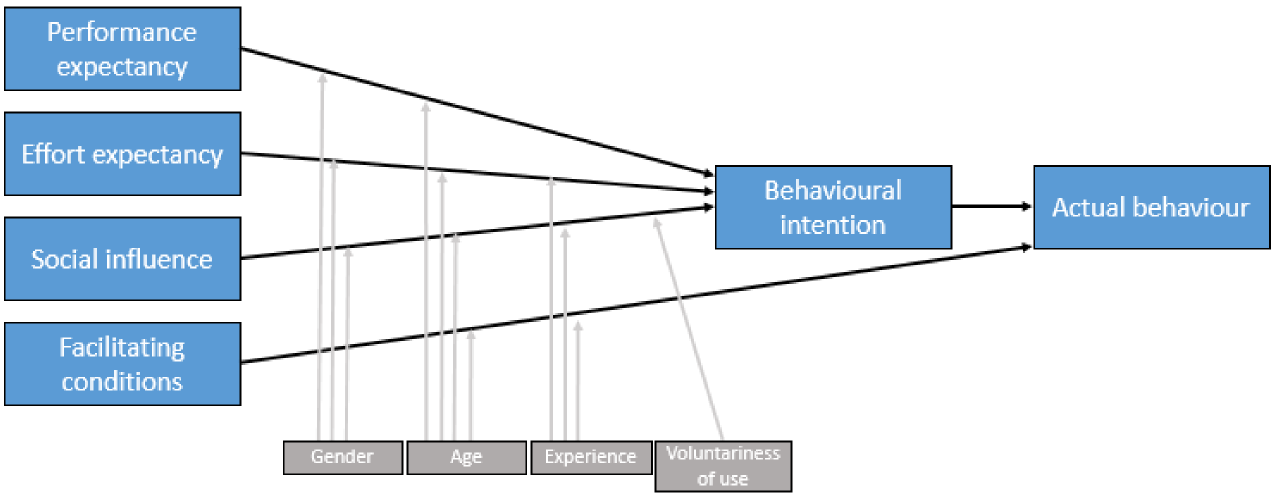

Figure 6: Unified Theory of Acceptance and Use of Technology (adapted from Venkatesh et al. (2003))

Performance expectancy

The performance expectancy of shared modes is related to the perception of an individual with regard to the characteristics of the system. Wolf and Seebauer (2014) described this as the “perceived trade-off between costs and benefits of a certain travel mode”. The costs and benefits of a specific transport mode can be expressed in generalised travel costs, which contain travel time, travel costs and inconvenience costs (Koopmans et al., 2013). These characteristics should be comparable to the characteristics of regular transport modes in order to enhance the intention of using these shared modes.

In the case of shared vehicles, the travel time consists of access, in-vehicle, and egress time. The access and egress time depend on the distance to the shared modes. An increase in the availability and supply of shared modes leads to shorter access and egress travel times and better accessible places. This may increase the use of these modes (Hoenjet et al., 2018) and reduce the need for car ownership. Tingen (2019) conducted qualitative interviews among inhabitants of Utrecht and found that a short walking time to carsharing vehicles relative to the walking time to private vehicles would make carsharing more attractive. The respondents indicated that carsharing would be more attractive when having a walking time of one minute to carsharing spots and 10 minutes to private vehicles (Tingen, 2019). Furthermore, travel costs are an important determinant of the usefulness of shared modes. The costs generally consist of a subscription fee and the individual trip costs (e.g. Greenwheels (2019)). The costs of using shared modes should be comparable to the costs of the current travel modes to make it more attractive. Harms, Durand, Hoogendoorn-Lanser, and Zijlstra (2018) concluded that people are unable to estimate the travel costs of their private car possession in the current situation. People often underestimate these total costs, because they often exclude the fixed costs of the purchase, insurance and road tax in their cost calculation. This may be an obstacle when comparing the costs of the private car with the costs of the use of shared modes instead.

The third characteristic that may influence the choice for using shared modes is the inconvenience costs. Inconvenience is directly related to the comfort of the modes and the flexibility of the system. This aspect is also closely related to the ease of use. Easier use of the shared modes results in a higher comfort level of these modes. KiM (2015) concluded that one of the motives to use shared cars is the fact that there are no parking-related problems because of the reserved parking spots. The absence of paid parking and a high parking pressure increase the comfort of shared vehicles rather than private vehicles. On the other hand, while private vehicles can be used at any time, it is not always ensured that there is a shared mode available. This leads to longer access and egress travel times, which may disturb to stimulate people to make use of sharing systems and get rid of their car. Tingen (2019) investigated the preferred distribution of carsharing vehicles among thirteen inhabitants of Utrecht. This qualitative research showed that the inhabitants prefer at least two carsharing vehicles per carsharing spot or all carsharing vehicles at one spot in the neighbourhood. The first alternative forms a combination of minimum walking time and a higher chance of available carsharing vehicles, compared to having one vehicle per spot. The second alternative is mainly preferred because of the high availability of carsharing vehicles. The availability of shared modes and the flexibility of the system can be enhanced by the provision of different types of shared modes at one location in a mobility hub. Furthermore, the proximity of carsharing spots near access roads is another important aspect to increase the attractiveness of carsharing for people living within the inner-urban areas (Tingen, 2019). By contrast, inhabitants of out-of-town areas do not have a preference for these locations, which can be explained by their residential location which is often closer to access roads and due to less traffic and one-way roads. These people, in turn, indicate that safe locations and locations at main walking routes increase the attractiveness of carsharing.

Effort expectancy

The effort expectancy can be enhanced by lowering the threshold to use it. A lower threshold to use shared modes results in a higher comfort level and lower inconvenience costs. One of the ways to lower the threshold for using shared modes is by offering a system which is easy to use for everyone. For instance, the shared modes could be offered through one single mobility package Mobility-as-a-Service (MaaS). Hietanen (2014) defined MaaS as a mobility distribution model, which satisfies the major transportation needs of the users by offering mobility services through a single interface (Jittrapirom et al., 2017). By providing integrated multimodal transport services through one application, it offers an alternative for non-integrated transport services and car ownership (Arthur D. Little, 2018; Sochor et al., 2018). Other examples are the direct use of the shared modes without going through procedures and the choice for different tariff options.

Diffusion theory related to shared modes

While the previously discussed adoption theories describe how individuals make choices to adopt or reject an innovation, diffusion theory describes how innovation is adopted by the population over time (Rogers, 2003; Straub, 2009). The diffusion theory of innovation by Rogers (2003) distinguishes five categories of adopters of new technologies: innovators, early adopters, early majority, late majority, and laggards (see Figure 7). The most likely people to adopt for using shared modes are the first adopters of the innovation and can be classified as the innovators or early adopters.

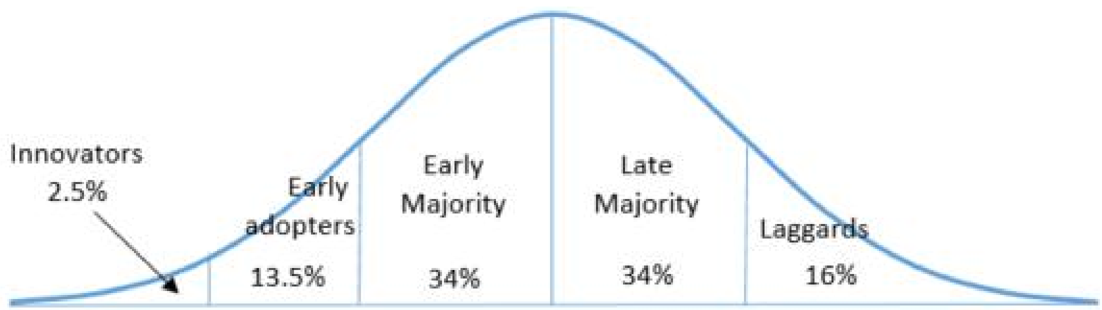

Figure 7: Diffusion theory by Rogers (adapted from Rogers (1962))

2.7 Conclusion

The constant increase in the number of private vehicles in the four largest cities in the Netherlands leads to parking-related problems since the vehicles are not used for more than 90% of the time (CBS, 2019a, 2019b; KiM, 2018). The expected population and employment growth in combination with the limited space in urban areas will ensure that the number of private vehicles and their parking related problems will increase in the future. A mobility system based on sharing instead of ownership can help to reduce household car ownership.

The most effective types of carsharing with regard to their effect on car ownership are known. It is concluded that the B2C-system is more effective than the P2P-system and that the round-trip B2C-system is more effective than the one-way B2C-system (KiM, 2015; Nijland & van Meerkerk, 2017). In contrary to carsharing, the effects of bicycle, e-bicycle, electric cargo bicycle and moped sharing on car ownership are unknown.

Shared modes can be offered separately or together in a mobility hub. Mobility hubs in the Netherlands have only been introduced through pilots and their effects on household car ownership are unknown. Additionally, the characteristics of these mobility hubs are not based on the effects of the individual characteristics on the use of the provided shared modes. The mobility hubs implemented outside the Netherlands are in densely populated urban areas with mixed land use and are close to public transport stops. The characteristics of these mobility hubs are also not based on the effects on the use of these shared modes and the reduction in car ownership. Therefore, it is expected that the currently provided shared modes in mobility hubs do not provide the most desirable effect on the usage and car ownership. This, in turn, could lead to unintended success and failure effects (Goudappel Coffeng, 2018).

In conclusion, previous research mainly focused on the separate effects of individual shared modes. The insight into the (potential) effects of shared modes provided together in mobility hubs is limited. The intention to use the shared modes provided by these mobility hubs as well as the potential effect on household car ownership are currently unknown. Additionally, the added value of mobility hubs over carsharing systems regarding these effects is unknown. Based on the discussed knowledge gap, the following problem definition has been defined:

Problem definition
The intention to use shared modes provided by mobility hubs and the potential effect of mobility hubs on household car ownership are currently unknown.

3 Research design

This chapter focuses on the research design, specifically with regard to the research objective, research questions and the scope of this research. The conclusion of the literature review indicates a research gap and a problem definition. The objective of this research is directly related to the problem definition. Subsequently, the main research question has been defined in line with the objective. This question has been decomposed into different sub-questions in order to achieve the objective. Furthermore, the scope has been defined in order to limit the focus of the research.

3.1 Research objective

The literature review of chapter 2 provides insight into the research gap. Based on that, the problem definition has been defined. The research objective relates directly to this problem definition, and has been formulated as follows:

Research objective
To investigate the characteristics that influence the intention to use shared modes provided by mobility hubs and to investigate the potential effect of mobility hubs on household car ownership

As previously discussed in the literature review, a mobility hub cannot be described in one way but is rather used as a term for different concepts where shared modes are offered together. In this research, a mobility hub is defined as a *location in a residential area, where shared cars, mopeds, e-bicycles and e-cargo bicycles are offered together*. The mobility hub focuses on the provision of transport by shared modes from the residential area towards the destination and back in order to replace car ownership. The characteristics of a mobility hub depend on the needs of the users. Therefore, it is not a foregone conclusion which characteristics a mobility hub has to contain. The effects of the characteristics of a mobility hub on the intention to use and the intention to reduce household car ownership have been investigated in this research.

3.2 Research questions

The main research question relates directly to the defined research objective. By answering the main research question, the objective of this research is achieved. The main research question is:

Main research question
What characteristics influence the intention to use shared modes provided by mobility hubs and what is the potential effect of mobility hubs on household car ownership?

In order to answer the main research question, the following sub-questions have been answered:

1. What are the characteristics of existing shared mode systems and mobility hubs in the Netherlands?
2. What characteristics influence the intention to use shared modes provided by mobility hubs and to what extent do these characteristics differ between mobility hubs and carsharing systems among residents of the investigated neighbourhoods in The Hague?
3. What is the potential effect of mobility hubs on household car ownership in the investigated neighbourhoods in The Hague and what characteristics are associated with a reduction in household car ownership when providing mobility hubs in these neighbourhoods?
4. What are the possible barriers for inhabitants of the investigated neighbourhoods to reduce household car ownership when providing mobility hubs in their neighbourhood?

3.3 Scope

The scope of this research is described below with regard to the included shared modes, the mobility hub characteristics, investigated neighbourhood type and location choice.

Shared modes

The considered shared modes include the shared car and light electric vehicles (moped, e-bicycle, e-cargo bicycle). The shared bicycle is out of the scope of this research because almost all inhabitants of The Netherlands own a bicycle. Consequently, they have access to a bicycle at the access side of their trip, which makes a shared bicycle in a mobility hub unnecessary. As previously discussed, the e-scooter is currently not allowed in the Netherlands. Therefore, the shared e-scooter is excluded from this research. Shared modes can be either offered in a B2C- or P2P-system. The focus of this research is on the characteristics of mobility hubs in a B2C-system. The investigation of the willingness of people to share their car is out of the scope of this research (P2P-system).

Mobility hub characteristics

The effects of mobility hub characteristics on the intention to use and intention to reduce household car ownership have been investigated. Other car ownership related measures which could be taken by municipalities, such as the implementation of higher parking fares and limited parking supply, are excluded from this research. Push measures in transport policy are perceived as unfair and unacceptable (e.g. Eriksson, Garvill, and Nordlund (2008)). Including push measures may also disturb the achievement of the objective, which specifically focuses on the effect of the mobility hub characteristics and not on the effect of these characteristics in combination with other measures.

Neighbourhood type

This research focuses on existing neighbourhoods because of several reasons. Firstly, the target group is easier to approach because these people are inhabitants of the concerning neighbourhoods. Secondly, the socio-demographic characteristics and the level of household car ownership are known. This makes it easier to assess the representativeness of the sample and to relate the effects of mobility hubs to the socio-demographic characteristics of the inhabitants and characteristics of the specific neighbourhood. Although inhabitants may have lived in the existing neighbourhood for years, the external effect of residential self-selection cannot be excluded since inhabitants could have made their residential location choice based on their preferences regarding travel behaviour. Furthermore, it should be noted that only people now living within these neighbourhoods are included in this analysis and not people who could move to the investigated neighbourhoods in the future.

Location

This research focuses on a specific research area in order to investigate the potential effects of mobility hubs in the context of specific neighbourhoods. As discussed in the literature review, car ownership related problems occur in the four largest cities in the Netherlands: Amsterdam, The Hague, Utrecht and Rotterdam. Due to the urban population and employment growth in combination with the limited urban space, these problems will increase in the coming years. Therefore, the transition from a mobility system based on car ownership towards a mobility system based on sharing is most important in urban areas. This research specifically focuses on The Hague. Both car ownership (the number of vehicles owned by 1,000 inhabitants) and the absolute number of private cars has increased in The Hague over the last ten years (CBS, 2019a, 2019b). Besides, the Municipality of The Hague showed their interest and would like to cooperate in the distribution of the survey.

Household car ownership in the different neighbourhoods *(Dutch: wijk)* of The Hague has been visualised by using QGis and is depicted in Figure 8. It should be explicitly noted that the data of the Municipality of The Hague (2019) have been used. In contrary to the data of CBS (2018a), the municipality did not include the data of fleet-owners (e.g. leasing companies), because these vehicles are mainly used elsewhere instead of in the registered neighbourhood. In order to calculate the exact level of car ownership, the municipality advised to increase the levels of private car ownership by 10% in each neighbourhood (Municipality of The

Hague, 2019). Based on the private car ownership data, it is concluded that the lower levels of household car ownership can be found in the inner city of The Hague, while higher levels of car ownership can be found further away from the city centre. This research focuses on neighbourhoods with a household car ownership of more than 0.65 car/household. These neighbourhoods have an above-average household car ownership since the average level of household car ownership is 0.66 cars/household in The Hague (Municipality of The Hague, 2019). Furthermore, it is more likely that households in these neighbourhoods have more private cars. Previous research showed that households with more cars are more likely to reduce household car ownership (Münzel, Piscicelli, et al., 2018; Nijland et al., 2015). Therefore, the supply of shared modes is probably more effective in these neighbourhoods compared to neighbourhoods with lower levels of household car ownership.

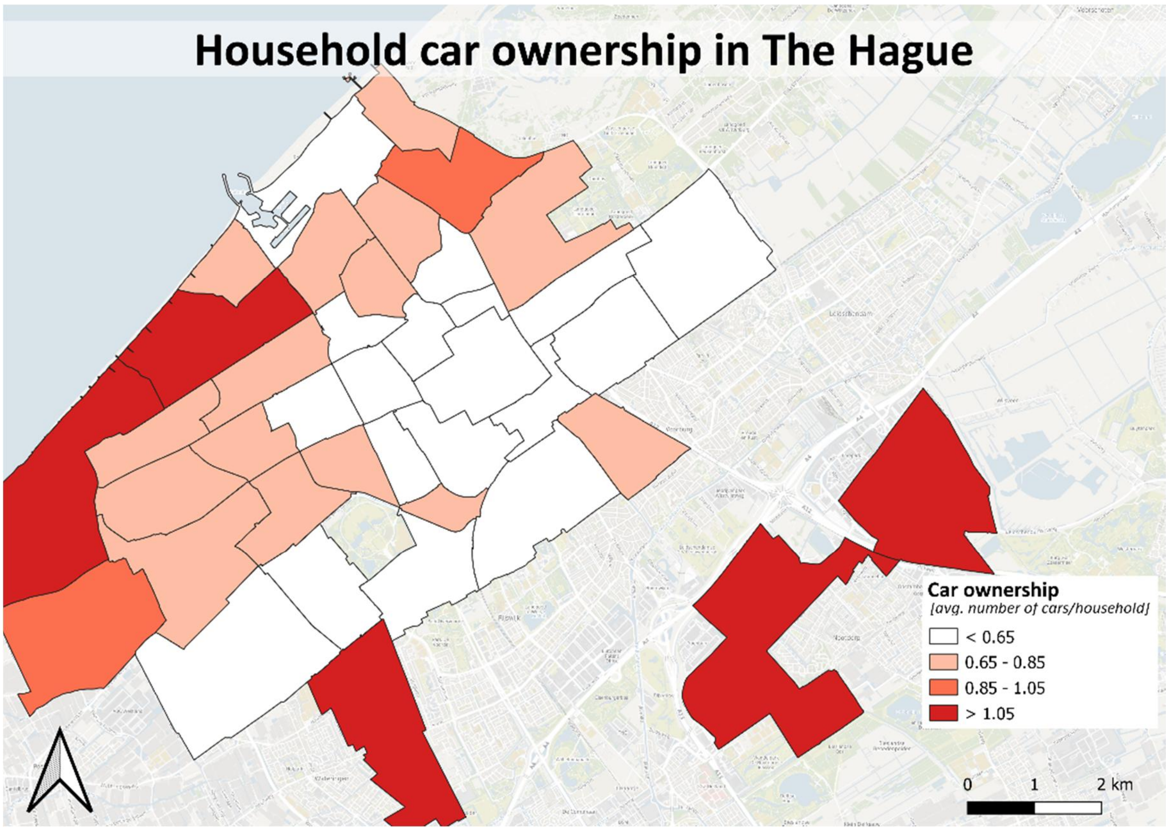

Figure 8: Car ownership in The Hague, data retrieved from the Municipality of The Hague (2019)

4 Methodology

The first part of this research is qualitative and focuses on the identification of the characteristics of existing shared mode systems in the Netherlands (section 4.1). Subsequently, the second part of this research is mainly quantitative and focuses on the intention to use shared modes provided by mobility hubs and the intention to reduce household car ownership (section 4.2).

This research is based on the theoretical framework depicted in Figure 9. The framework is based on the Unified Theory of Acceptance and Use of Technology (UTAUT), which has been discussed in section 2.6. The UTAUT also incorporates the relationship between the intention to use and actual use and the relationship between facilitating conditions and actual use. Since the purpose of this study is to investigate the potential effect of non-existing hubs with specific characteristics, these relationships have not been investigated during this research. In addition, the UTAUT assumes that attitude towards using technology is not a direct determinant of intention (Venkatesh et al., 2003). However, many studies, including the Theory of Planned Behaviour, show that attitudes are a determinant for the intention to use (Ajzen, 1991; Dwivedi et al., 2019). Moreover, it is expected that attitudes towards shared modes and car ownership affect the intention to use shared modes (section 2.2). Therefore, the relationship between attitudes and the intention to use the mobility hub is also included in the theoretical framework. Furthermore, the relation between socio-demographic (SD) characteristics and the intention to use has been included as well, since some population groups may be more/less likely to have the intention to use shared modes (section 2.3.1).

The theoretical framework shows that the performance expectancy, effort expectancy, attitudes, social norm, and socio-demographic characteristics affect the intention to use the mobility hub. The intention to use the mobility hub may result in the intention to reduce household car ownership and other effects. The investigation of other effects, such as the effect on car use, is beyond the scope of this research. The objective of this research is *"to investigate the characteristics that influence the intention to use shared modes provided by mobility hubs and to investigate the potential effect of mobility hubs on household car ownership"*. Therefore, the relationships between the performance expectancy, effort expectancy, attitudes, social norm, socio-demographic characteristics, the intention to use the mobility hub and the intention to reduce the level of household car ownership have been investigated. Since attitudes, social norm, socio-demographic characteristics and current travel behaviour affect household car ownership (section 2.2), the association between these variables and the intention to reduce household car ownership has been investigated as well.

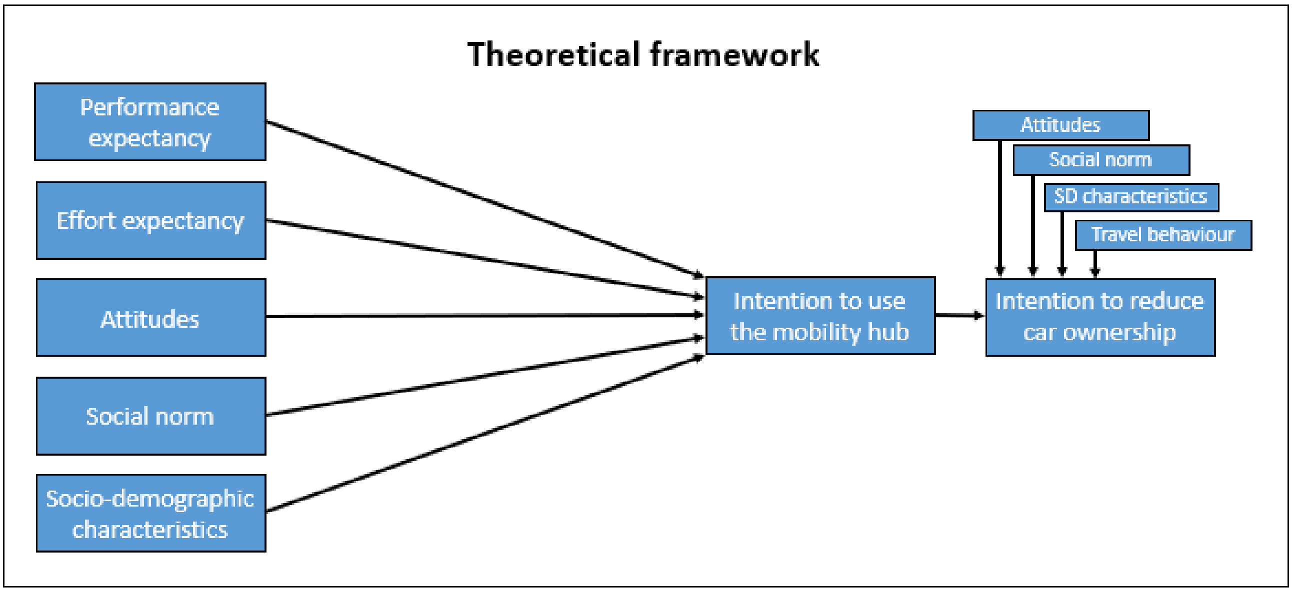

Figure 9: Theoretical framework

4.1 Analysis of existing shared mode systems in the Netherlands

The analysis of existing shared mode systems aims at investigating the characteristics of existing shared mode systems in The Netherlands (research question 1). Before investigating these characteristics, an overview of the different suppliers and the locations of these suppliers has been made by using the websites and mobile applications of the suppliers. As previously discussed in section 2.6, the characteristics that may influence the use of shared modes and the relinquishment of private cars relate to travel costs, travel time and inconvenience costs (Koopmans et al., 2013). These characteristics have been investigated for the existing shared mode systems in the Netherlands, as discussed below.

Travel costs and inconvenience costs

The travel costs and comfort of the different shared mode systems in the Netherlands have been investigated by exploring the websites and mobile applications of the suppliers. Additional information about the maximum acceptable distance and system characteristics (e.g. costs, supply) has been retrieved by personal communication with the following experts:

- Marco Boender, Chief Sharing Officer at Fetch
- Robert Bosman, business development lead Belgium & the Netherlands at Car2Go
- Alicia Hobbel, location manager at Greenwheels
- Daan Wijnants, head of public affairs at Felyx

Travel time

The travel time consists of access, in-vehicle, and egress travel time. The access travel time has been investigated for all dwellings in The Hague. Since the supply of shared modes differs across the neighbourhoods, the share of dwellings within a certain distance has been analysed for all neighbourhoods in The Hague. The analysis of the walking time towards shared modes has been investigated for all station-based shared mode systems in The Hague since the locations of these shared modes are fixed. The analysis has been performed by using QGIS (QGIS Development Team, 2019).

All addresses in The Hague have been imported from Kadaster (2019), the road network has been imported from OpenTransportMap (2019) and the polygons of the neighbourhoods have been imported from CBS (2018b). Information about the specific neighbourhood *(wijk)* has been added to the residential addresses by using the function “add polygon attributes to points”. The locations of the shared modes have been explored by using websites and mobile applications. Afterwards, the data of the locations have been imported into QGIS by using the plug-in “MMQGIS”.

The service areas of 100, 200 and 500 meters of a shared mode have been defined by using the function “service area (from layer)” with the road network as network and the shared mode locations as starting points. Subsequently, the roads have been split into road sections of 10 meter by using the function “vector split” to easily assess which dwellings are within a specific service area. Finally, the share of dwellings within a specific distance of a shared mode has been calculated for each neighbourhood in The Hague. This provides general insight into the distribution of dwellings within a certain distance of a shared mode.

4.2 Analysis of the potential effects of mobility hubs

The main part of this research focuses on the potential effects of mobility hubs. A survey is the most suitable medium to achieve this objective since the respondents could be faced with non-existing mobility hubs with specific characteristics. Hence, the main part of the survey is the stated preference part of the survey that focuses on hypothetical situations, in which the respondent chooses for the alternative he/she prefers when facing the same situation in the real world (Train, 2009). This makes it possible to measure the effect on the usage, without the implementation of all different possible combinations of mobility hub characteristics. Durand et al. (2018) concluded that car ownership decisions are often taken on a household level and advised to use households as the unit of research. This research also addresses car ownership decisions. Therefore, the survey focuses on the household level as well. Research questions 2 up to 4 have been investigated by conducting a survey. More explanation about the survey design can be found in chapter 6, whereas the results of the survey analysis are presented in chapter 7.

5 Analysis of existing shared mode systems in the Netherlands

This chapter presents the results of the analysis of the characteristics of existing shared mode systems and mobility hubs in the Netherlands. All shared modes are shortly described with regard to their suppliers, service areas and type of systems (section 5.1). The characteristics that may influence the use of shared modes and the relinquishment of private cars relate to travel costs, travel time and inconvenience costs (Koopmans et al., 2013). These characteristics may influence the performance expectancy and effort expectancy of the mobility hubs and the provided shared modes. Therefore, the existing shared mode systems and mobility hubs are discussed with regard to the travel costs, travel time and inconvenience costs in the subsequent sections (section 5.2-5.4). The travel costs incorporate the registration, subscription and usage fees (see Figure 10). The travel time relates to the access travel time, in-vehicle travel time and egress travel time. The inconvenience costs or comfort aspects relate to the system characteristics, the availability of the offered shared modes, the booking application, the users and the included vehicles and their properties.

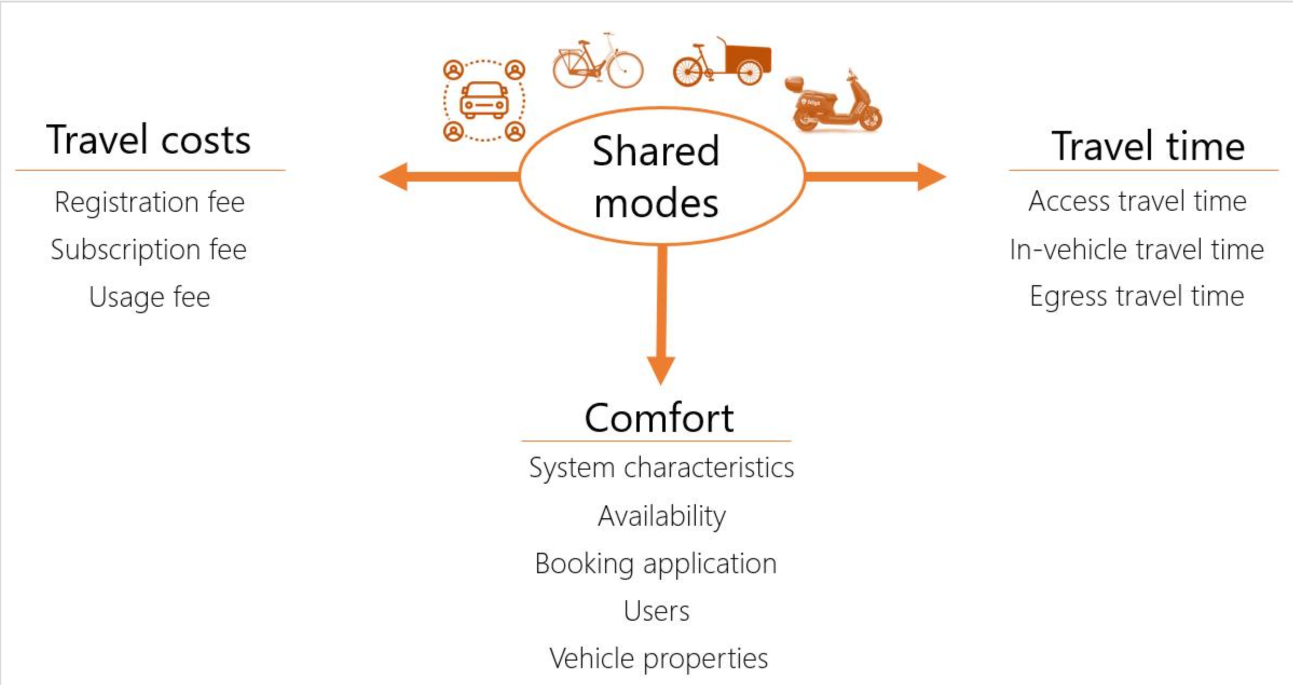

Figure 10: Characteristics of existing shared mode systems and mobility hubs

5.1 Overview

This section presents an overview of the suppliers, service areas and type of systems of the existing shared mode systems in the Netherlands. Shared cars, mopeds, e-(cargo)bicycles and bicycles are consecutively discussed below. Additionally, an overview of the round-trip locations of suppliers in The Hague is presented.

Shared cars

One-way carsharing suppliers Car2Go and Fetch operate with respectively 350 and 200 shared vehicles in Amsterdam (Fetch, 2019; Municipality of Amsterdam, 2019). The maximum number of free-floating vehicles has been restricted by the municipality. Additionally, Witkar provides a one-way carsharing system with drop off zones covering the cities Groningen and Rotterdam (Witkar, 2019). Besides, shared cars of Witkar can be brought back to relatively small drop off locations in designated areas in 30 other Dutch cities. In contrary to one-way carsharing, round-trip carsharing can be found widespread over the Netherlands. Greenwheels, MyWheels, ConnectCar and Buurauto are all round-trip carsharing suppliers. Greenwheels is the largest operator with 1,700 vehicles in the Netherlands, including 162 vehicles in The Hague (Greenwheels, 2019). MyWheels has 275 shared vehicles in the Netherlands, of which 12 vehicles in The Hague (MyWheels, 2019). ConnectCar mainly operates in Utrecht and Amsterdam and the surroundings of Amsterdam (ConnectCar, 2019). Buurauto operates in neighbourhoods in several cities in the Netherlands, including seven locations in The Hague (Buurauto, 2019).

Shared e-mopeds & e-(cargo)bicycles

The shared e-moped systems of Felyx and Gosharing are both free-floating systems. Felyx operates in Amsterdam (100 e-mopeds), Rotterdam (640) and The Hague (200), whereas GoSharing operates in Eindhoven (160) and Rotterdam (500) (Felyx, 2019; GoSharing, 2019). The shared e-bicycle system of JUMP is also free-floating and operates only within Rotterdam (500 bicycles) (Keswiel, 2019). In contrary, the electric (and conventional) bicycles of Donkey Republic in Rotterdam should be returned to one of the drop off locations (Donkey Republic, 2019). Cargoroo is the only supplier of e-cargo bicycles in the Netherlands. The station-based system of Cargoroo operates in The Hague (50 bicycles) and Haarlem (5) (Cargoroo, 2019).

Shared bicycle

Shared bicycle systems in the Netherlands can be divided into one-way (HTM-bicycle, MoBike) and round-trip (PT-bicycle) systems. HTM-bicycles are distributed over 71 locations near public transport stops of public transport company HTM and should be brought back to one of these locations (HTM, 2019). Since these locations are well distributed over the city, it can be considered as a one-way bicycle system. The bicycles of MoBike should not be dropped at fixed locations and are therefore completely free-floating. MoBike operates in The Hague (500 bicycles), Delft and Rotterdam (AD, 2018). The locations of the round-trip PT-bicycle-system are stations of the Dutch Railways. In The Hague and surroundings, the PT-bicycle can be found at railway stations Den Haag CS (549 bicycles), Den Haag HS (108), Den Haag Laan van NOI (26), Den Haag Mariahoeve (9), Rijswijk (17), Voorburg (13) and Delft (272) (NS, personal communication, November 21, 2019).

In addition to the offered shared mode systems, there are some suppliers of mobility hubs, such as Beamrz, Hely and Huub. These companies offer different shared modes together at several locations in the Netherlands. These mobility hubs are also located in the Binckhorst and Bezuidenhout (Hely) and Harvest (Huub) in The Hague and consist of shared cars and e-cargo bicycles of Cargoroo.

Shared modes in The Hague

An overview of the shared mode systems in The Hague is shown in Figure 11. It should be noted that the e-mopeds of Felyx and bicycles of MoBike are not included in the map since these systems are free-floating. The other shared mode systems are round-trip systems or have fixed drop off locations. Hence, the locations of the HTM-bicycle are also included in the figure. HTM regularly checks whether there are sufficient bicycles at each location (HTM, 2019). When considering the relation between household car ownership and the supply of shared modes (see Appendix A1), it is concluded that the majority of the existing shared modes are situated in neighbourhoods with an below-average level of household car ownership (<0.65 cars/household).

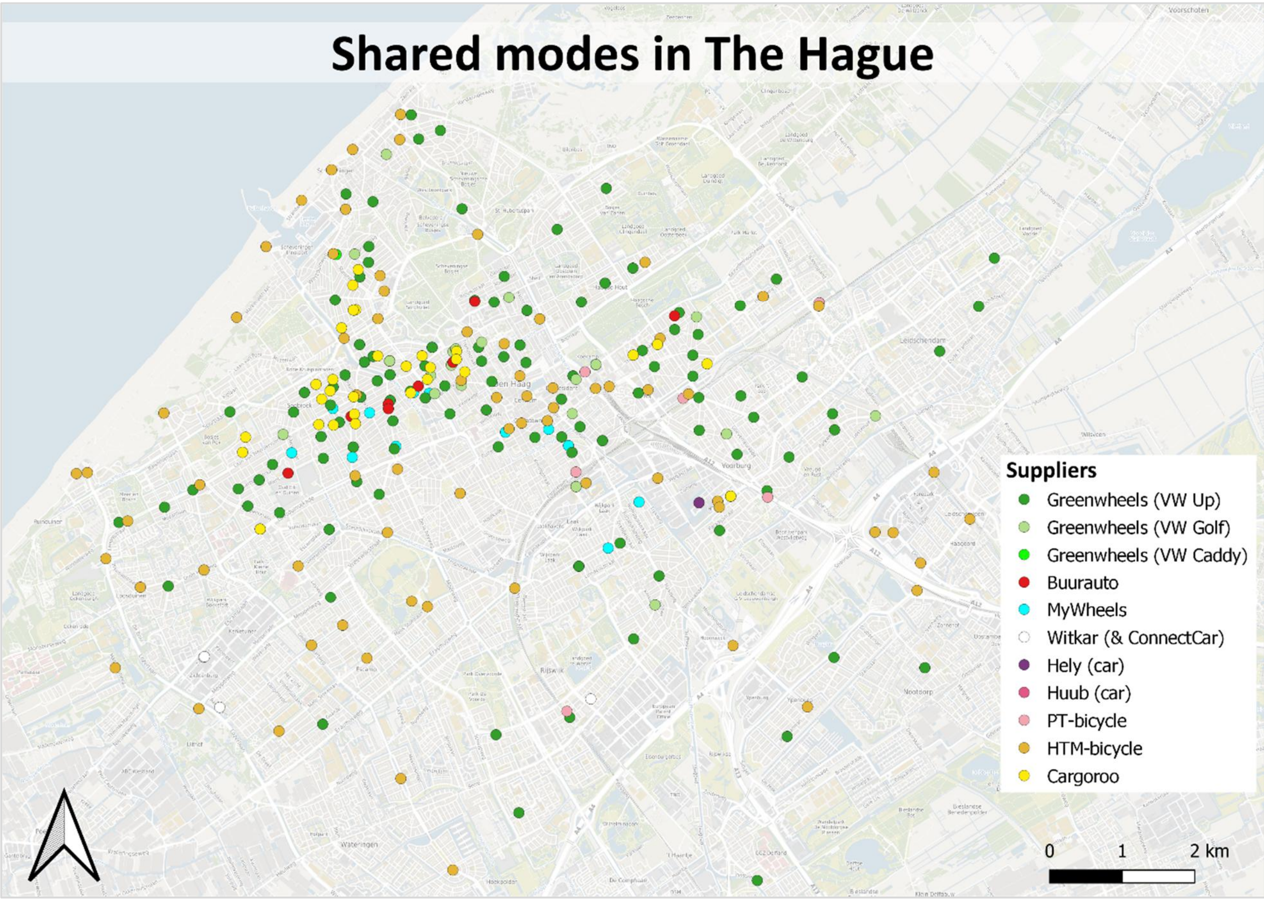

Figure 11: Overview of shared modes in The Hague (except Felyx & MoBike), based on (Buurauto, 2019; Cargoroo, 2019; ConnectCar, 2019; Greenwheels, 2019; Hely, 2019; HTM, 2019; MyWheels, 2019; NS, 2019b; Witkar, 2019)

5.2 Travel costs

The costs for private car ownership include fixed and variable costs. The fixed costs of car ownership incorporate all costs that a vehicle owner must pay independent of the time and distance travelled (Duncan, 2011). The fixed costs include depreciation, private motor vehicle and motorcycle tax, maintenance, and insurance costs, whereas the variable costs are the depreciation, fuel, maintenance and reparation costs (Duncan, 2011; Nibud, 2018). In contrary to private car ownership, (car)sharing has a different price structure. The fixed costs of car ownership are nearly all transformed in variable costs and all costs are distributed across use (Prettenthaler & Steininger, 1999). The price structure in case of sharing is usually defined as pay-as-you-go since the total costs are largely based on the variable costs for using. The payment for sharing usually consists of a registration fee, membership fee and a usage rate (Duncan, 2011). The usage rate can either be based on the rental duration only with a maximum distance that may be travelled or a combination of rental duration and distance travelled (Nickerson, Remane, Hanelt, Tesch, & Kolbe, 2017).

The costs for the different shared modes depend on the organisation (Duncan, 2011). An overview of the costs of the existing B2C-shared mode systems in the Netherlands is attached in Appendix A2. The registration fee is between €0 and €25, dependent on the organisation and shared mode. In the case of Buurauto, Car2Go, Fetch and Felyx, the users receive credits for free driving in return for the registration fee. The monthly subscription fee is in the case of almost all organisations for free. Only Greenwheels and Buurauto require a subscription fee for different types of subscriptions. As a result of paying a subscription fee, the user pays fewer variable costs for the duration and distance travelled. In accordance with literature studies, the usage rate depends on the duration or a combination of duration and distance travelled. Car2Go, Witkar, Fetch, Felyx, GoSharing, Cargoroo and the suppliers of shared bicycles all require duration costs only. Car2Go indicated that this is mainly due to the limited distance covered by free-floating cars (R. Bosman, personal communication, December 20, 2019). This can be explained by the limited service area, which generally covers only one city. When buying a Car2Go package, there are additional distance costs in the case of expiring the maximum number of kilometres. Witkar requires additional costs in the case of more than 50 km per hour, with increasing costs for more distance travelled. Fetch requires additional costs for distances of more than 250 km. In contrary to the suppliers of one-way systems, the suppliers of round-trip carsharing (Greenwheels, MyWheels, ConnectCar and Buurauto) require costs for both duration and distance travelled. Concerning the shared cars of ConnectCar, the costs for distance travelled are decreasing in the case of more than 100 km. All round-trip carsharing systems offer different shared vehicles, which have their usage costs, based on the level of comfort. In addition to the costs for duration and distance travelled, MyWheels, ConnectCar, Cargoroo and JUMP require additional costs per usage time.

The providers of mobility hubs use the same price structure as the individual shared modes (Appendix A3). However, the usage costs generally consist of costs for the duration only. In addition to the usage costs, Hely requires a subscription fee of € 4.95 per month. The subscription fees of Huub and Beamrz vary among the different type of subscriptions. In the case of Huub, lower subscription fees result in higher usage costs. On the contrary, users of Beamrz receive more comfort in return for the higher subscription fees (section 5.4).

Cost comparison private and shared car

"A key element to the potential growth of carsharing is its ability to provide cost savings to those who adopt it in favour of vehicle ownership" (Duncan, 2011). So, participating in sharing is most beneficial for people who have lower costs for sharing compared to private car ownership. The estimation of car ownership costs could form a bottleneck, since car owners are unable to estimate these costs (Harms et al., 2018). Different studies made a comparison of the costs of private car ownership and carsharing. Litman (2015) and Nibud (2018) concluded that carsharing is a cost-effective alternative for private car ownership when driving less than 10,000 km per year. Since the costs of sharing vary among the number of usage times, duration, distance travelled and used modes, it is context-dependent whether sharing is more cost-effective than private car ownership. Additionally, the costs of private car ownership depend on the vehicle class and model (Nibud, 2018). An overview of the monthly costs of private cars and round-trip carsharing is depicted in Figure 12. The costs of private car ownership are based on Nibud (2018).

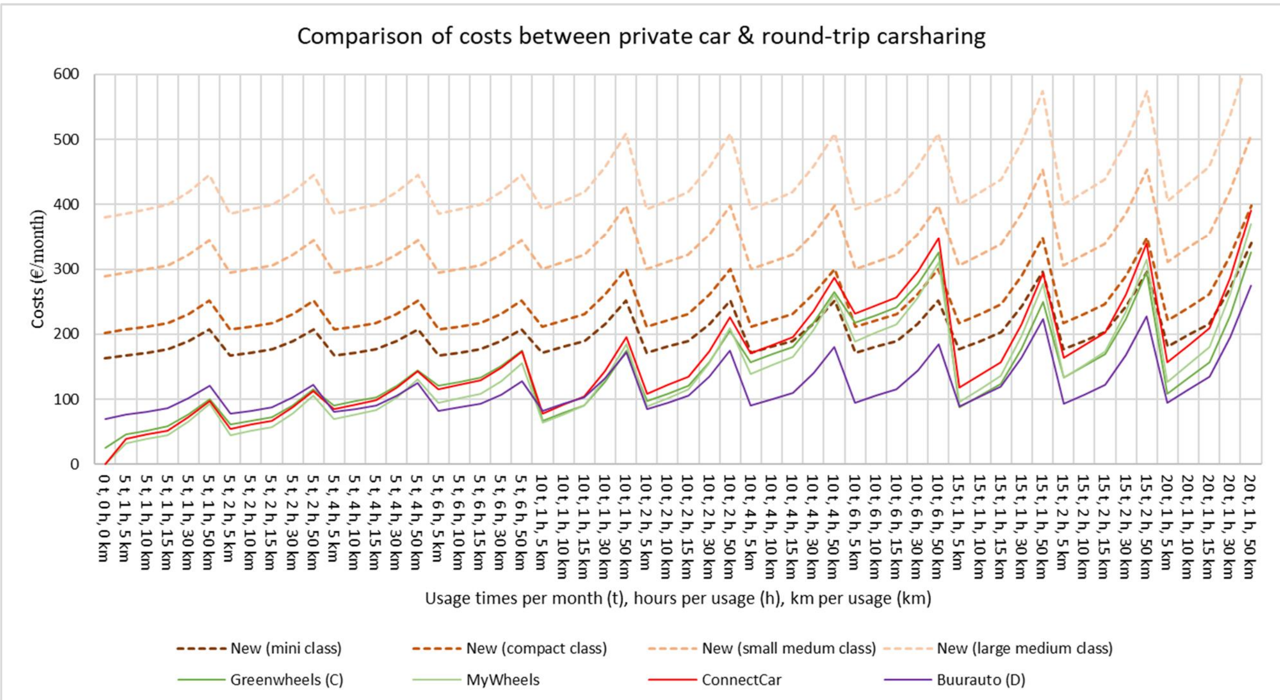

Figure 12: Comparison of the costs of private car ownership and round-trip shared cars

Figure 12 shows that, initially, all suppliers of round-trip carsharing are cheaper than private car ownership due to the relatively high fixed costs of owning a private car and the relatively low fixed subscription costs of the shared modes. The costs of Greenwheels, MyWheels and ConnectCar are comparable: the costs increase proportionally with increasing durations and distances. There are different intersection points of the costs of a new mini class car and the costs of these shared cars. The costs of Greenwheels, MyWheels and ConnectCar and the new mini class car are approximately equal at 10 usage times per month of 4 hours and 50 km, and 15 usage times per month of 2 hours and 50 km. This is equal to 6,000 and 9,000 km per year. The distance of 9,000 km is comparable to previous research, although the distance of cost-effective carsharing depends on the usage times, hours and km per usage. On the other hand, Buurauto (subscription D) is significantly cheaper than private car ownership in all discussed situations (see Figure 12). In contrary to the other round-trip systems, the subscription costs per month are relatively high, which results in fewer variable costs. The mini class car has approximately the same price per month as Buurauto in the case of 20 usage times/month of 10 hours and 80 km, which is equal to around 19,000 km/year. This means that the shared car of Buurauto is even an attractive transport mode for people who regularly use their car, assuming that the shared car of Buurauto is always available for usage. It is concluded that the cars of Buurauto are an attractive alternative for 64.5% of the cars since the yearly distance of these cars is less than 15,000 km/year (see Appendix A4). Additionally, it is concluded that the cars of Buurauto are more attractive for non-first cars in households as the share of cars with a yearly distance of less than 15,000 km is larger (71.3%) than for first cars (61.5%).

In contrary to round-trip carsharing, the rental period of one-way carsharing can be terminated at the trip destination. This, in turn, leads to short rental periods, since the residence time at the destination does not cost anything. Thus, these systems are cheaper in comparison with most round-trip carsharing systems in the case of relatively long residence times and short driving periods. However, one-way carsharing is usually provided in urban areas, which means that the rental period cannot be terminated outside the city. So, out-of-town trips are relatively expensive because of the relatively high costs per minute in comparison with round-trip carsharing. The costs of the one-way shared cars of Car2Go, Fetch and Witkar have also been compared with the costs of private car ownership (see Appendix A5). It is concluded that one-way carsharing is generally cheaper than private car ownership in the case of 20 times of 30 minutes or 10 times of 1 hour, independent of trip distance. This means that one-way carsharing is also cheaper in the case of 40 times of 15 minutes. This indicates that the shared car is cheaper for commuting trips if the commuting time is less than 15 minutes, assuming 20 commuting days per month. When considering the distribution of travel times of commuting trips (see Appendix A6), one-way carsharing is attractive for 17.6% of the commuters in The Netherlands. The potential for very densely populated areas where one-way carsharing systems are usually implemented is considerably lower: 11.5% of the commuting trips is less than 15 minutes. It should be noted that the car is also used for other purposes, which leads to a lower share of the population.

When using shared modes instead of private car ownership, small car distances can be covered by other shared modes (e.g. moped, e-(cargo)bicycle), which are usually cheaper. This makes sharing more cost-effective compared to carsharing only.

5.3 Travel time

The travel time of shared modes usually consists of access, in-vehicle and egress travel time. As discussed in the literature review, the access travel time depends on the availability of the shared modes in the proximity of the origin of the trip. The egress travel time, in turn, depends on the distance from the parking spot (round-trip system) or return location (one-way system) to the destination of the trip.

Acceptable distance to shared cars

The different suppliers do not use the same maximum acceptable (walking) distance to shared cars. The mobile application of Car2Go suggests that the acceptable range is 900 meters since users can search vehicles nearby within a range up to 900 meters (Car2Go, 2019). However, R. Bosman (Car2Go, personal communication, December 20, 2019) concluded that the maximum acceptable range is around 300 meters, dependent on the travel purpose and destination of the trip. Fetch uses maximum acceptable access walking times of 5 up to 10 minutes (M. Boendel, personal communication, December 16, 2019). Greenwheels uses the same acceptable access time but concludes that this depends on a wide variety of factors, including the level of urbanisation (A. Hobbel, personal communication, November 21, 2019). Additionally, Greenwheels indicated that the majority of the users live within a distance of 300 meters of a shared car, which is similar to the maximum acceptable distance used by Car2Go. The Municipality of The Hague uses a maximum acceptable access distance of 500 meters (S. Mittertreiner, personal communication, December 5, 2019).

Access travel time to shared modes

The access travel time has been calculated for the different station-based shared mode systems in The Hague. The access travel time has been expressed in the share of dwellings in The Hague within 100, 200 and 500 meters of a shared mode. Shared modes within 100 and 200 meters are in the proximity of the dwellings. The distance of 500 meters is equal to the maximum acceptable service area of a local bus stop, which is usually between 400 and 500 meters (van der Blij, Veger, & Slebos, 2010). This corresponds to 6 minutes walking or 2 minutes cycling, considering an average speed of 5 km/h (walking) and 15 km/h (cycling).

The share of dwellings within 100, 200, and 500 meters of a shared car, bicycle and e-cargo bicycle is shown in Figure 13. Around 8% of the dwellings are within 100 meters of a shared car, 14% of the dwellings are within 200 meters of a shared car, and 33% of the dwellings are within 500 meters of a shared car. The shares of dwellings within these distances of a shared (e-cargo)bicycle are considerably smaller. Furthermore, it is concluded that access travel times to shared modes vary over the different neighbourhoods. Therefore, the access travel times in the different neighbourhoods are further discussed for these shared modes.

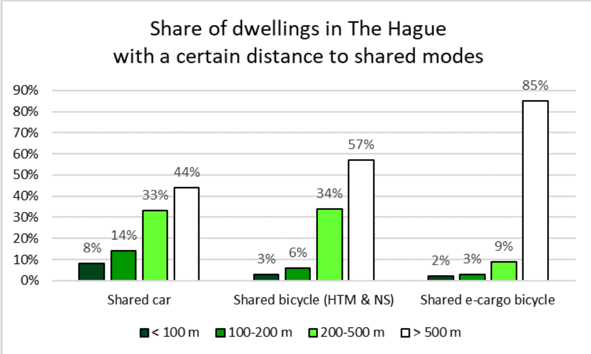

Figure 13: Share of dwellings within a certain distance of a shared car, bicycle (HTM and NS) and e-cargo bicycle

Shared car

Figure 14 shows that the shared cars are disproportionally distributed over the city. The central parts of The Hague are well covered by the defined service areas, which means that the network distance is less than 500 meter. In contrary, the suburban neighbourhoods have less shared cars, which results in smaller residential areas covered by the defined service areas. This means that most inhabitants of these neighbourhoods do not have access to a shared car in the proximity of their dwelling. The largest supplier of shared cars in The Hague, Greenwheels, indicates that there is insufficient demand for at least one car if there are no Greenwheels vehicles in a neighbourhood (A. Hobbel, personal communication, November 21, 2019).

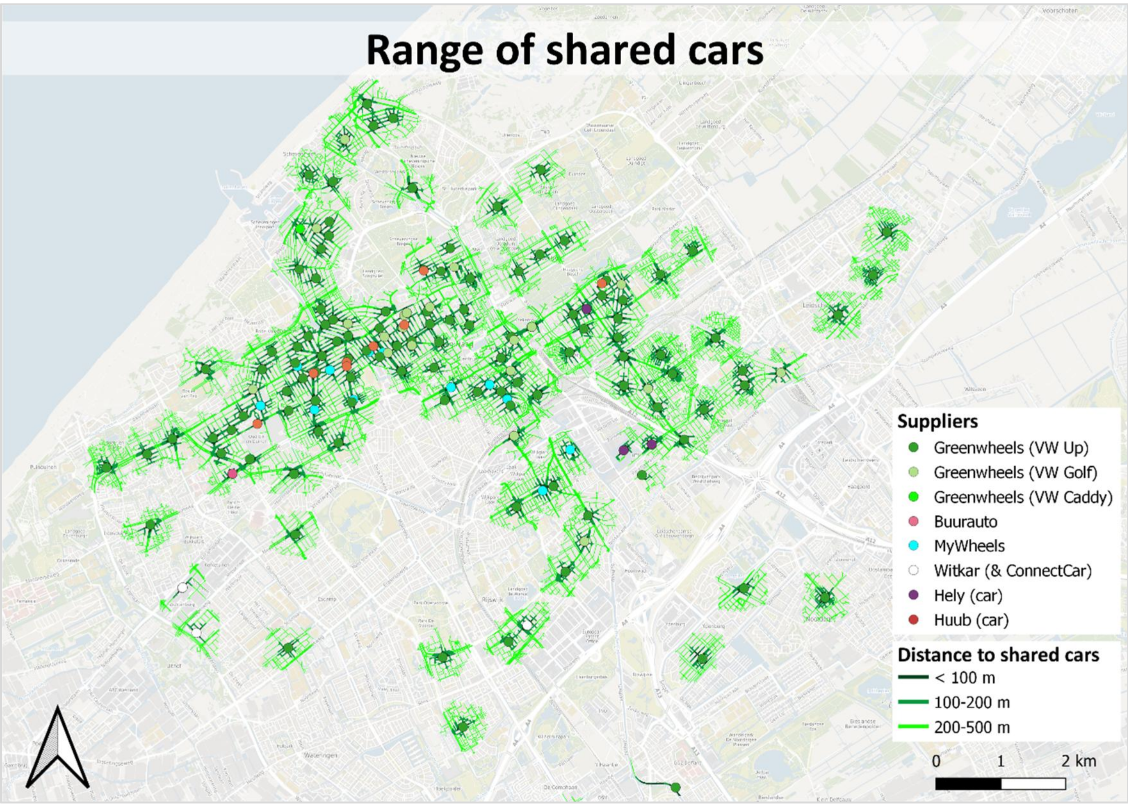

Figure 14: Overview of distribution of shared cars in The Hague and network distance to those shared modes

The share of dwellings within 100, 200 and 500 meters of a shared car per neighbourhood in The Hague is depicted in the pie charts in Figure 15. The largest share of dwellings within 100 meters can be found in the neighbourhoods Zeeheldenkwartier (38%), Regentessekwartier (31%), and Archipelbuurt (28%). Interesting to note is that more than 90% of the dwellings are within 500 meters of a shared car in 14 neighbourhoods in The Hague. This means that almost all dwellings within these neighbourhoods are within 6 minutes walking and 2 minutes cycling of a shared car.

Besides the availability of a shared mode in the neighbourhood, it is also interesting to consider the number of shared cars within the proximity of the dwellings. When a shared car is already in use and not available, the inhabitant is forced to use another shared car in the proximity of their dwelling. The number of shared cars per ha per neighbourhood is also depicted in Figure 15 (indicated with the colour of the neighbourhood). It should be noted that this is rather an indication of the distribution since it could still be the case that the shared vehicles are disproportionally distributed over the neighbourhood. It is concluded that the neighbourhoods that have the highest share of dwellings within 100, 200 and 500 meters of a shared car are also the neighbourhoods that have the largest number of shared cars per ha.

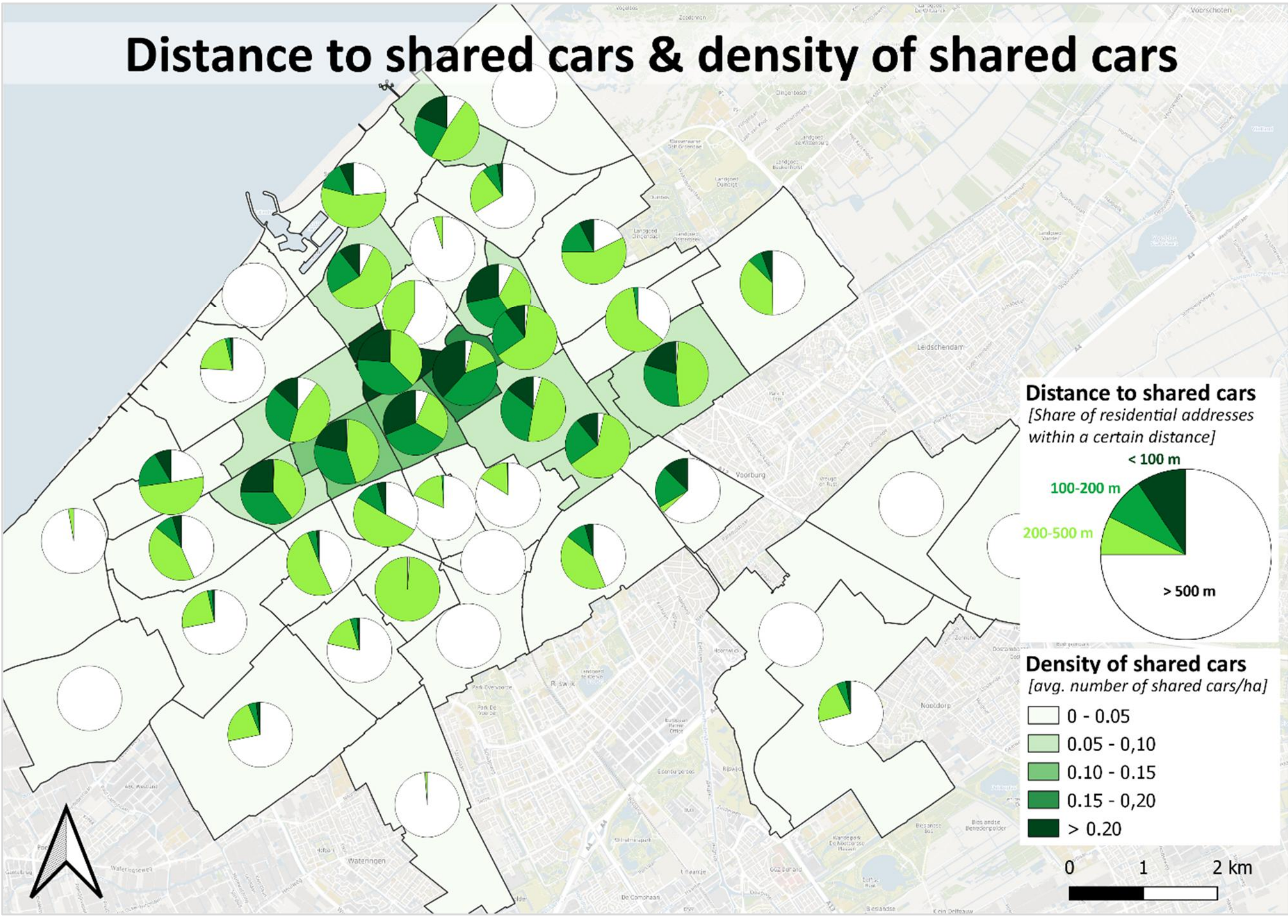

Figure 15: Share of dwellings within 100, 200 and 500 meters of a shared car and the average number of shared vehicles/ha

Shared bicycles

The distances from the dwellings to shared bicycles have been analysed for the station-based PT-bicycle and HTM-bicycle. The share of dwellings within 100, 200 and 500 meters of a bicycle location is depicted in the pie charts in Figure 16. The share of dwellings within 100 and 200 meters of a shared bicycle is smaller in comparison with the shared cars. Since almost all inhabitants of the Netherlands own a bicycle (Martens, 2007), the shared bicycle is mainly an interesting supplement as an egress mode for public transport trips. When using the shared bicycle as egress mode, a relatively large share of dwellings is within 500 meters of a shared bicycle. These dwellings can be reached within two minutes cycling, considering a cycling speed of 15 km/h.

The share of dwellings within 100, 200 and 500 meters of a shared e-cargo bicycle is depicted in Figure 17. The largest share within 100 meters can be found in Zeeheldenkwartier (20%) and Bomen- & Bloemenbuurt (17%), which contain respectively five and seven e-cargo bicycles spread over their neighbourhood. Besides, the largest share of dwellings within 500 meters can be found in Duinoord (99%), followed by Zeeheldenkwartier (91%) and Bomen- & Bloemenbuurt (76%).

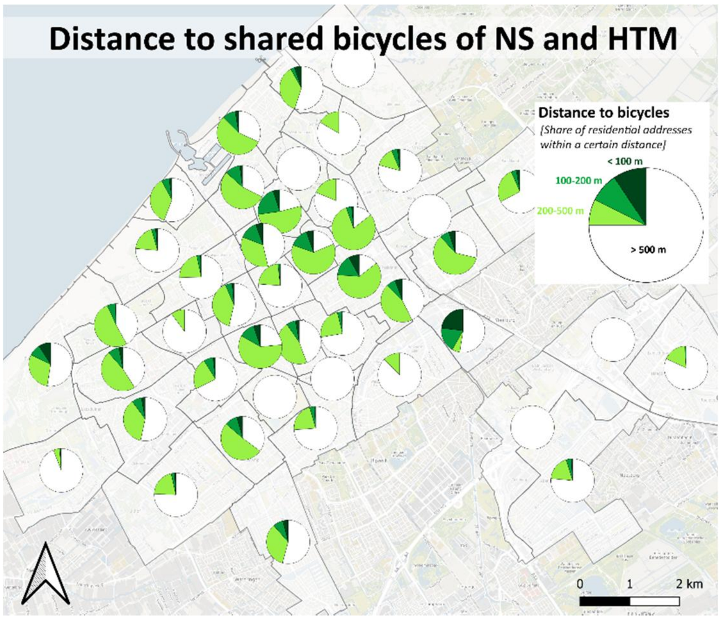

Figure 16: Share of dwellings within a certain distance of shared bicycles

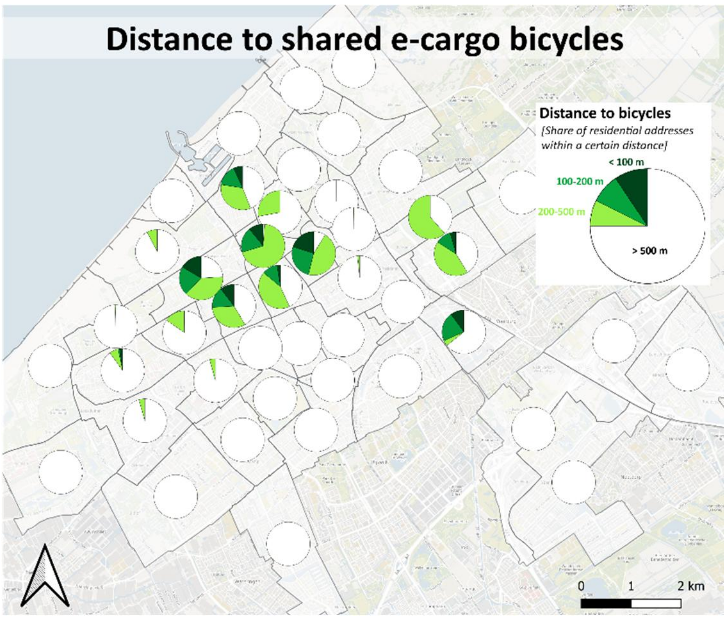

Figure 17: Share of dwellings within a certain distance of e-cargo bicycles

Shared e-mopeds

The shared e-moped system of Felyx is a free-floating system, which means that the access (walking) time varies over time. There is even no redistribution of the e-mopeds when the e-mopeds are disproportionally distributed over the neighbourhoods (D. Wijnants, personal communication, December 6, 2019). Since the availability of the e-mopeds differs over time, no conclusions can be made about the walking time on an average day. The distribution of e-mopeds is therefore shortly discussed on a Tuesday and Thursday (26 and 28 November 2019) and is attached in Appendix A7. The shared e-mopeds are quite well distributed over the different neighbourhoods before the morning peak on both days. After the morning peak on Tuesday, the e-mopeds are mainly located in and around the city centre, the business area around Utrechtsebaan, Duinzigt, and Binckhors. In contrary, the e-mopeds are better distributed over the neighbourhoods after the morning peak on Thursday. Additionally, the e-mopeds are better distributed over the neighbourhoods before and after the evening peak on Thursday, whereas there is a higher concentration of e-mopeds in and around the city centre after the evening peak on Tuesday. Therefore, it is concluded that the distribution and access walking times even vary among the days of the week in addition to the time of the day. In the case of large concentrations of e-mopeds, the walking time is less than 100 meters, whereas smaller concentrations indicate that the walking time is even larger than 500 meters.

Availability of multiple modes in the proximity of the dwellings

It has been investigated to what extent multiple shared modes are currently available in the proximity of the dwellings to assess the possible added value of mobility hubs. As described before, the shared bicycle is usually considered as an egress transport mode. Therefore, it has been investigated to what extent the shared car and e-cargo bicycle are available in the proximity of dwellings (see Table 1). It is concluded that respectively 0.8% of the dwellings are within 100 meters of both a shared car and e-cargo bicycle. Around 4% of the dwellings are within 200 meters of a shared car and e-cargo bicycle. Additionally, around 15% lives within 500 meters of both modes. So, a relatively small share of households lives within an acceptable distance of multiple shared modes. Furthermore, it should be noted that these modes are most often not provided at the same location. Therefore, it is concluded that the mobility hub, in which multiple shared modes are provided together, could be of added value in addition to the existing shared mode systems.

Table 1: Multiple modes in the proximity of dwellings in the Hague

			Shared e-cargo bicycle			
			< 100 m	**100-200 m**	**200-500 m**	**> 500 m**
			2.1%	***3.4%***	***9.4%***	***85.1%***
Shared car	**< 100 m**	***8.4%***	0.8%	1.0%	2.0%	4.6%
	100-200 m	***14.4%***	0.7%	1.5%	3.2%	8.9%
	200-500 m	***33.1%***	0.5%	0.9%	4.0%	27.7%
	> 500 m	***44.1%***	0.1%	0.1%	0.1%	43.9%

5.4 Inconvenience costs

The inconvenience costs relate to the comfort aspects of the shared modes. These aspects are closely related to the comfort of the modes and the flexibility of the system, as discussed in section 2.6. The most important comfort aspects of the shared mode systems in the Netherlands are summarized in Appendix A8. These comfort aspects include the system characteristics, availability of offered shared modes, the booking application, the users and the included vehicles and their properties.

System characteristics

System characteristics are the type of system, (size of the) service area, deposit, own risk, minimum rental period, and the maximum number of users. The type of system strongly influences the flexibility of the system. For instance, the rental period of one-way sharing can be terminated at the trip destination, which may result in lower travel costs since the rental duration is relatively short. On the other hand, no shared mode might be available nearby when returning to the origin. In contrary, round-trip vehicles should be brought back to the origin of the trip which results in longer rental durations, which may lead to higher usage costs. The size of the service area differs among the one-way systems. The service area of Car2Go almost covers the whole city of Amsterdam, except some northern, western and south-eastern parts of Amsterdam. The service area of Fetch is almost similar to Car2Go, although the northern part of Amsterdam is completely excluded from the service area. Furthermore, there are some additional drop off zones which require an additional fee. For instance, Car2Go cars can be dropped at Schiphol Airport in return for an additional fee of € 8.90. The service area of Witkar covers Groningen and Rotterdam and some relatively small drop off zones distributed over other cities in the Netherlands. This means that the vehicles of Witkar can be used to travel to other cities, although the egress travel time may be substantial due to the limited number of drop off zones. Felyx, Go sharing, JUMP, DonkeyRepublic and MoBike have service areas which cover the major part of the city centre in which the shared system operates. Besides, all free-floating shared mode systems in the Netherlands have free parking within their service areas.

Possible additional costs such as a deposit and own risk costs in case of damage/theft can obstruct people to use shared mode systems. A deposit is usually charged to ensure payment for possible damage, fines and other violations (Greenwheels, 2019; Litman, 2015; Seik, 2000). The majority of the suppliers of shared modes do not require a deposit but rather a verification of the driver license or bank account. For instance, Car2Go only requires verification of the driver license since a flexible free-floating concept should be easily accessible for potential users (R. Bosman, personal communication, December 20, 2019). However, ConnectCar, Greenwheels and Witkar require a deposit of €100 (ConnectCar, Witkar) or €225 (Greenwheels). The deposit of Greenwheels can also be satisfied with the registration of the users' credit card. The own risk costs are between €0 and €500, dependent on the shared mode and supplier. The own risk costs can be reduced by an additional fee, which can be paid per trip (Greenwheels, MyWheels), per day (DonkeyRepublic) or per month (Buurauto). The minimum rental period of the shared modes depends on the type of system. The one-way systems usually have a minimum rental period of 1 minute, while the round-trip systems generally have a minimum rental period of 15 minutes. Most suppliers of shared modes only allow the registered person to use shared modes, except for Greenwheels (subscriptions B and C), Buurauto, Cargoroo, DonkeyRepublic, PT-bicycle and HTM-bicycle.

Availability of offered shared modes

The availability of offered shared mode strongly depends on the number of vehicles provided by the suppliers and the density of the vehicles (see section 5.3). Besides, when a shared mode is not available anymore, another mode in the proximity should be available to maintain the same access travel time. Greenwheels is the largest supplier of shared cars in The Hague. The largest supplier of shared e-mopeds is Felyx, whereas the largest supplier of e-cargo bicycles is Cargoroo. These suppliers also have the largest density of the offered modes, although the modes are usually disproportionally distributed throughout The Hague. The largest suppliers of bicycles are MoBike, NS and HTM. The bicycles of MoBike (free-floating) and HTM (station-based free-floating) can be found throughout The Hague. In contrary, the shared bicycles of NS can only be found at NS-stations and are more disproportionally distributed than MoBike and HTM-bicycle.

Booking application

The shared mode systems in the Netherlands can usually be booked on an application. The only exception is the PT-bicycle which does not have an application and can only be booked at the location itself. In contrary to the shared mode systems, mobility hubs offer multiple shared modes through one application. For instance, Hely and Huub provide electric bicycles, cargo bicycles and cars through one interface, while Beamrz provides one platform for car- and bicycle sharing and public transport. Beamrz also serves as a payment method for public transport (including PT-bicycle), refuelling and parking, when having the more expensive subscription (€ 14.90 instead of € 9.90). Most suppliers of shared modes have a reservation option in their booking application to ensure that the vehicle is available at the desired moment. All round-trip carsharing systems can be booked in advance for any specific date and time. In contrary, the suppliers of other shared modes do have maximum reservation times beforehand. Users are not ensured that there is a shared mode available nearby, although the user is more flexible to use a shared mode spontaneously. Fetch, Felyx, GoSharing and MoBike do have a maximum reservation time of 15 minutes, while the maximum reservation time of Car2Go and Cargoroo is 20 minutes. The maximum reservation times of JUMP and HTM-bicycle are respectively 5 and 30 minutes beforehand.

Users

Usually, users do not know the other users of the shared mode system. The shared mode is shared with unknown people since every user can use the shared mode if available. In contrary, the shared cars of Buurauto are shared by fixed groups of neighbours. Three up to five households conclude a contract with Buurauto (Verkeersnet, 2016). Thereafter, the shared car is available for use for these households.

Vehicle properties

Furthermore, the shared vehicles differ in their vehicle properties, e.g. the number of seats, luggage space, availability of navigation and MP3. The preferred vehicle properties may also depend on the situation, type of trip and number of people travelling with. Additionally, the fuel type of shared cars may influence the level of comfort of shared modes. In the case of electric-driven vehicles, the vehicles have a maximum range when fully charged. The different suppliers inform the user about the actual battery range via the application. Users of Car2Go are encouraged to charge the vehicle when the battery range drops below 30% by receiving credits of € 4 on their account (Car2Go, 2019).

5.5 Conclusion

The existing shared mode systems and mobility hubs in the Netherlands, and more specifically in The Hague, do have different characteristics regarding the travel costs, travel time and inconvenience costs. These characteristics vary over the different suppliers and their shared modes.

Since the fixed costs of existing shared mode systems and mobility hubs are relatively low, the travel costs mainly depend on the usage fees, based on the duration only (one-way) or a combination of duration and distance (round-trip). Shared cars of Greenwheels, MyWheels and ConnectCar are cheaper than a private mini class car, when driving 6,000 up to 9,000 km/year, although this depends on the usage times, distance travelled, and the rental duration. The shared car of Buurauto is even cheaper than a private mini class car at 20 usage times per month of 10 hours and 80 km per month, which is equal to around 19,000 km/year. Furthermore, the existing shared mode systems and mobility hubs differ in (access) travel time and inconvenience costs. System characteristics, the availability of the offered shared modes, the reservation option, the users and the included vehicles and their properties differ over the suppliers and shared modes. The availability of the shared modes depends on the number of vehicles and density of the vehicles, which influence the access travel time.

The access travel time towards the shared modes differs among the shared modes and neighbourhoods. Based on GIS-analysis of the access travel time towards shared modes in The Hague, it is concluded that around 8% of the dwellings are within 100 meters of a shared car, whereas respectively 3% and 2% of the dwellings are within 100 meters of a shared bicycle and shared e-cargo bicycle. Besides, around 15% of the dwellings are within 500 meters of both a shared car and e-cargo bicycle. This indicates that mobility hubs could provide additional value compared to existing shared mode systems in The Hague. Furthermore, it is concluded that the distance to the shared modes varies among the different neighbourhoods in The Hague. For instance, 38% of the dwellings in Zeeheldenkwartier are within 100 meters of a shared car, whereas none of the dwellings in Leidschenveen are within 100 meters of a shared car. In order to investigate the differences in potential effects of mobility hubs, neighbourhoods with a different proximity to shared modes have been selected (see section 6.5). Neighbourhoods with a relatively high share of dwellings within 100, 200 and 500 meters of a shared car are selected to investigate the potential effects in neighbourhoods that are familiar with shared modes, whereas neighbourhoods with a relatively low share of dwellings within these distances are selected to investigate the neighbourhoods that are less familiar with shared modes.

6 Survey design

The main purpose of this research is *"to investigate the characteristics that influence the intention to use shared modes provided by mobility hubs and to investigate the potential effect of mobility hubs on household car ownership"*. This objective has mainly been answered by conducting a survey. The survey aims at answering research questions 2 up to 4. The survey consists of four parts:

1. Introduction & questions about actual behaviour and car ownership
2. Stated choice experiments
3. The potential effect on household car ownership
4. Questions about socio-demographic characteristics

The structure of the survey is depicted in Figure 18.

The stated choice experiment is explained in detail in section 6.1, the questions about the potential effect on household car ownership are explained in section 6.2, whereas the introduction and the additional questions before and after the main part of the survey are explained in section 6.3. Subsequently, the focus is on testing the survey (section 6.4), the data collection (section 6.5) and the survey analysis (section 6.6).

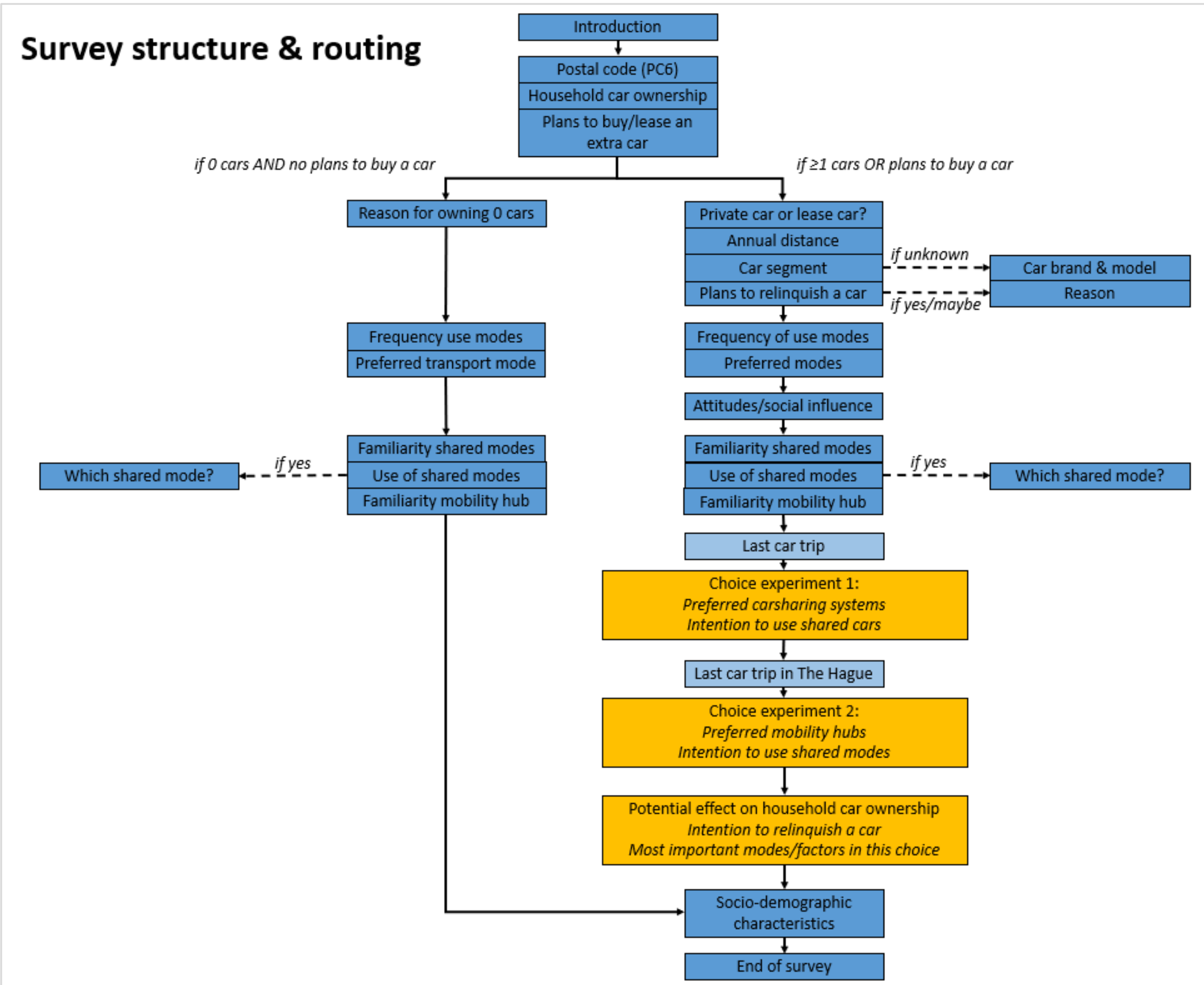

Figure 18: Survey structure and routing

6.1 Design of discrete choice experiment

The experimental design process as defined by Hensher et al. (2005) has been used to construct the design of the discrete choice experiments. The first stage of the experimental design process is the problem refinement. This stage has been investigated in the literature review (see chapter 2). Subsequently, the alternatives, attributes and attribute levels are identified in the stimuli refinement stage. The third stage focuses on experimental design considerations, such as the reduction of the experimental size into a fractional factorial design. Afterwards, the experimental design and choice sets are generated and randomized. Finally, the construction of the survey is performed. The survey in this research has been constructed by using Qualtrics software (Qualtrics, 2020).

Accordingly, the following steps are further explained in this section:

1. Identify alternatives (section 6.1.1)
2. Identify attributes and attribute levels (section 6.1.2)
3. Combine characteristics to get profiles (section 6.1.3)
4. Design of fractional factorial design (section 6.1.4)
5. Generation and randomisation of choice sets (section 6.1.5)

The survey consists of two discrete choice experiments, aimed at investigating the intention to use shared modes. Hence, the objective of the first choice experiment is to investigate the characteristics that influence the intention to use shared cars provided by carsharing systems. In order to enhance the choice context, this experiment focuses on the last car trip from the respondent's dwelling. The objective of the second choice experiment is to investigate the characteristics that influence the intention to use shared modes provided by mobility hubs. The second choice experiment focuses on a short distance trip in order to assess the additional value of a moped, e-bicycle and e-cargo bicycle provided by mobility hubs. Therefore, this choice experiment focuses on the last car trip from the respondent's dwelling to a destination in The Hague. When the last car trip from the respondent's dwelling has already been made to a destination in The Hague, the second choice experiment does have the same choice context as in the case of the first choice experiment. Accordingly, the last car trip from the respondent's dwelling to a destination in The Hague has not been asked before the second choice experiment since the trip is the same. In the case of planned household car ownership, the last trip instead of the last car trip has been used in both experiments.

6.1.1 Identify alternatives

The first step in the construction of the choice experiment is the definition of the alternatives. Since the potential effect of a carsharing system and a mobility hub are investigated, there is only a single alternative: the carsharing system (experiment 1) or the mobility hub (experiment 2). Choice experiments with a single alternative are called unlabelled choice experiments. Unlabelled choice experiments are constructed "to examine different (potential) configurations of a single alternative, although this need not be the only choice setting" (Hensher et al., 2005). Accordingly, the alternatives in the choice experiments are unlabelled:

- *System A*, *System B* and *None* (experiment 1)
- *Mobility hub A*, *Mobility hub B* and *None* (experiment 2)

The names of the unlabelled alternatives only indicate the relative order of appearance (Rose & Bliemer, 2009). Thus, the heading of each alternative is uninformative to the decision-maker (Hensher et al., 2005). Also, letters instead of numbers are used to avoid any connection with a ranked sequence. The alternatives only differ in their attributes and attribute-level labels (Hensher et al., 2005). Hence, both provided systems or mobility hubs in a choice set contain different characteristics. The definition of these profiles can be found in section 6.1.4. According to Hensher et al. (2005), including an opt-out option is "a decision that must be made in the light of the objective of the study". However, neither of the carsharing systems or mobility hubs may be preferred for specific trips or when the respondent could not choose between two systems with (in the opinion of the respondent) equally (dis)advantageous characteristics. Therefore, an opt-out option has been included as additional answer.

Each choice set of both experiments contains two questions. The first question focuses on the preferred carsharing system or mobility hub for the specific trip. The second question focuses on the preferred mode

for the specific trip and is only asked if the respondent chooses a preferred system. The respondent was able to choose either their car (or current mode in the case of planned car ownership) or the shared car of the preferred carsharing system in the first experiment. The respondent was able to choose between their car (or current mode) and the shared modes of the preferred mobility hub in the second experiment.
The questions in each choice set have been formulated as:

1. "You would make your last car trip from your dwelling (to a destination in The Hague) again.
   You can use two possible carsharing systems/mobility hubs.
   Which carsharing system/mobility hub do you prefer?"
   Answers experiment 1: System A, System B and *None*
   Answers experiment 2: Mobility hub A, Mobility hub B and *None*
2. "Which transport mode do you prefer for this trip?"
   Answers experiment 1: car and *shared car (of preferred carsharing system)*
   Answers experiment 2: car, shared car, moped, e-bicycle, e-cargo bicycle (of preferred mobility hub)

6.1.2 Identify attributes and attribute levels

Subsequently, the attributes and attribute levels of the carsharing systems and mobility hubs are defined. The attributes of a carsharing system or mobility hub are based on the characteristics of existing shared mode systems (see chapter 5) and are expressed in travel costs, travel time, and comfort. The comfort of the mobility hub mainly relies on the flexibility of the system. The flexibility of the mobility hub relates to the type of system (return location) and the reservation time. Additionally, the influence of the type of users has been investigated. According to the theoretical framework, all these attributes are incorporated in the performance and effort expectancy of the mobility hub. The number of attributes included in the stated choice experiment should be limited in order to restrict the final number of choice sets and prevent information overload to the respondent. For instance, Caussade, de Dios Ortúzar, Rizzi, and Hensher (2005) investigated the influence of design dimensions on stated choice experiment estimates and concluded that a higher number of attributes has a detrimental effect on the choice ability of the respondent. This, in turn, leads to a higher error variance in the results. Therefore, the number of attributes in this discrete choice experiment have been limited to respectively five and six characteristics. The defined attributes and attribute levels are summarized in Table 2 and Table 3. The attribute levels of walking time (both experiments) and travel costs (carsharing system) are ordered in ascending size to investigate the effect of increasing walking time and travel costs. In contrary, the travel costs of the mobility hub are ordered in descending size, so the effect of decreasing costs of the other shared modes compared to the costs of the shared car (€0.40/km) can be investigated. Besides, a zero is assigned to attributes which are most common for existing mobility hubs (return to pick-up point, no reservation required, known/unknown users). Consequently, the effects of changing these characteristics can be investigated.

Table 2: Overview attributes, levels and effect coding experiment 1-A

Attribute	Level	Attribute levels	Effect coding		
Walking time *(W)*	0	3 minutes	1	0	
	1	6 minutes	0	1	
	2	9 minutes	-1	-1	
Travel Costs *(T)*	0	€ 0.20 / km	1	0	0
	1	€ 0.30 / km	0	1	0
	2	€ 0.40 / km	0	0	1
	3	€ 0.50 / km	-1	-1	-1
Return location *(RL)*	0	Return to pick-up point	1		
	1	No return needed	-1		
Reservation *(R)*	0	Not needed	1	0	
	1	Min. 30 minutes before	0	1	
	2	Min. 1 hour before	-1	-1	
Users *(U)*	0	Known/unknown users	1		
	1	Only with known users	-1		

Table 3: Overview attributes, levels and effect coding experiment 2

Attribute	Level	Attribute levels	Effect coding		
Supply *(SP)*	0	Moped, e-bicycle, e-cargo bike	1		
	1	Car, moped, e-bicycle, e-cargo bicycle	-1		
Walking time *(W)*	0	3 minutes	1	0	
	1	6 minutes	0	1	
	2	9 minutes	-1	-1	
Travel Costs *(T)*	0	€ 0.40 / km	1	0	0
	1	€ 0.30 / km	0	1	0
	2	€ 0.20 / km	0	0	1
	3	€ 0.10 / km	-1	-1	-1
Return location *(RL)*	0	Return to mobility hub	1		
	1	No return needed	-1		
Reservation *(R)*	0	Not needed	1	0	
	1	Min. 30 minutes before	0	1	
	2	Min. 1 hour before	-1	-1	
Users *(U)*	0	Known/unknown users	1		
	1	Only with known users	-1		

Supply
The supply in the first experiment is fixed to the shared car to investigate trade-offs in characteristics of a carsharing system and the intention to use shared cars. In contrary, the supply in the second experiment varies between the moped, e-bicycle, e-cargo bicycle, and these modes in combination with the shared car. In this way, the additional value of the other shared modes in a mobility hub has been investigated. Accordingly, trade-offs between the supply of the mobility hub and other characteristics can be found. When the respondent would only like to use a car, he/she always chooses the mobility hub with a shared car. In order to determine the additional value of the other shared modes included in the mobility hub, it has been investigated under which circumstances the respondent is willing to choose for a mobility hub without a shared car.

Walking time
The travel time depends on the access, in-vehicle and egress travel time. The in-vehicle travel time depends on the speed of the shared mode. The access and egress travel time can be expressed as walking time towards the carsharing system or mobility hub. Three levels of walking time are defined to investigate the effect of higher densities of carsharing systems or mobility hubs, which generally leads to shorter walking times. The intervals between the different walking times are equal in order to investigate whether the effect is linear or not. The Municipality of The Hague uses a maximum acceptable range of 500 meters in the case of carsharing (S. Mittertreiner, personal communication, December 5, 2019), which is similar to 6 minutes walking time. This corresponds to the maximum acceptable range of a local bus stop (van der Blij et al., 2010). Therefore, 6 minutes of walking time is included as an attribute level. Since Car2Go and Greenwheels indicated that the acceptable walking distance of the majority of the users is around 300 meters, a walking time of 3 minutes is also included as attribute level. A walking time of 9 minutes is included to investigate the effect of a relatively long distance towards the system or mobility hub.

Travel costs
The travel costs of shared modes usually depend on the rental duration and the distance travelled (see section 5.2). Since we are primarily interested in the trade-offs between costs and other characteristics and to simplify the choice complexity for respondents, the costs are expressed in €/km. Besides, the rental duration strongly depends on the return location, which makes a time-dependent cost indicator less suitable. The cost levels in the first experiment are based on the current costs of shared cars and private cars (see Appendix B1). Accordingly, realistic included cost levels are €0.20/km, €0.30/km, €0.40/km and €0.50/km. People with plans to buy a car are probably more likely to prefer monthly subscription costs of a shared car rather than variable costs. Therefore, subscription costs of €50/month in return for 10 cent reduction in €/km (considering 6,000 km/year) are included as attribute levels for these respondents. In order to investigate the potential effect of shared modes provided by mobility hubs in the second experiment, the costs of the shared car are fixed to €0.40/km, whereas the cost levels of the other included shared modes vary between €0.10/km and €0.40/km. The attribute level of €0.40/km is included to investigate whether the other shared modes than the shared car are preferred in the case of equal costs. The other attribute levels are lower compared to the costs of a shared car to present realistic choice situations.

Return location
The comfort and flexibility of the system depend on the return location of the shared mode. The return location of a shared mode can be either the pick-up location or a flexible location somewhere else (no return needed), e.g. at the destination side of the trip. The first system is usually known as a round-trip system, whereas the latter system is a one-way system (see section 5.4). In this way, the effects of a more flexible system compared to a round-trip system have been investigated.

Reservation
The flexibility of the system also depends on the minimum required reservation time beforehand to ensure that a vehicle is available in the mobility hub. Most current suppliers of shared modes require a reservation beforehand. The reservation can usually be made from 1 minute up to 30 minutes beforehand or even for a specific date or time, dependent on the supplier of the shared mode (see section 5.4). In this way, users are

assured that the specific shared mode is available. In the case of a mobility hub, the effect of a minimum required reservation time has been investigated since a required reservation is less comfortable and flexible. Required reservation times of 0, 30 and 60 minutes are included as attribute levels. When there is no reservation required, the reservation time is equal to zero minutes. Minimum reservation times of 30 and 60 minutes provide insight into the effect of an increasing reservation time.

Users
The system can be either shared with known users as in the case of Buurauto (see section 5.4) or shared with both unknown and known users as the majority of the existing shared modes. In this way, it has been investigated to what extent the type of users affects the choice for a specific system and what the trade-offs between the type of users and the other characteristics are.

6.1.3 Combine characteristics to get profiles
The full factorial design can be constructed by varying all possible combinations of attribute levels (Puello, 2018). This results in a full factorial design of 144 profiles (3x4x2x3x2) in experiment 1 and 288 profiles in experiment 2. In a full factorial design, all attribute levels should occur the same number of times, which implies that the design is balanced (Puello, 2018). This has been ensured by checking the sum of the effect coding across all profiles. The used effect coding for the different attribute levels can be found in Table 2 and Table 3. The effect coding for a two-level attribute is *[1,-1]*, whereas the effect coding of a three- and four-level attribute are *[(1,0),(0,1),(-1,-1)]* and *[(1,0,0),(0,1,0),(0,0,1),(-1,-1,-1)]* (Arentze, Feng, Timmermans, & Robroeks, 2012; Hensher et al., 2005). The full factorial design can be found in Appendix B2. The full factorial design is orthogonal. Orthogonality implies that "the attributes presented to the individuals are varied independently from each other" (Hensher, 1994). This means that there is zero correlation between the attributes. A correlation test by using SPSS (IBM Corp., 2017) shows that the Pearson correlation between all attributes (except the attribute with itself) is indeed zero (r = 0.000), which implies no correlation. Besides the orthogonality of the individual attributes, the full factorial design is also orthogonal in terms of interaction terms (Rose & Bliemer, 2009). This means that one interaction term, the influence of two or more attribute levels multiplied together, is also not correlated with another attribute or interaction term. Again, a correlation test shows that the Pearson correlation is also zero (r = 0.000) among the interaction terms and between the interaction terms and attributes.

6.1.4 Design of fractional factorial design
A full factorial design usually consists of a relatively large number of profiles, which also leads to a relatively large number of choice sets when combining all profiles once. This could be a burden for the respondent and could cause survey fatigue, which may cause respondents to start adopting simplifying decision heuristics (Arentze, Borgers, Timmermans, & DelMistro, 2003). Therefore, a fractional factorial design has been constructed, which consists of a subset of profiles of the full factorial design (Rose & Bliemer, 2009). According to Rose and Bliemer (2009), the best known fractional factorial design type is the orthogonal design. To reduce the number of profiles, an orthogonal design has been generated by using the function "Generate orthogonal design" in SPSS (Hensher et al., 2005; IBM Corp., 2017). The minimum required profiles in the orthogonal design to estimate the main effects, the effects of the individual attributes, is based on the degrees of freedom (Hensher et al., 2005). When we assume that non-linear estimates are required, one degree of freedom is required in the case of a two-level attribute, two degrees of freedom are required in the case of a three-level attribute and three degrees of freedom are required in the case of a four-level attribute. In this research, the minimum degrees of freedom are respectively nine (experiment 1) and ten (experiment 2). In addition, Hensher et al. (2005) concluded that an additional degree of freedom is needed for the error component. Thus, the minimum degrees of freedom and the number of profiles are ten and eleven. Therefore, orthogonal designs of 16 profiles have been generated separately for both experiments.

The orthogonality of this design has been tested by the correlation test. Pearson correlation shows that there is no correlation between the attributes (r = 0.000), which implies that the fractional factorial design is orthogonal. The attribute levels of supply (experiment 2), travel costs, return location and users occur the same number of times, so these attributes are balanced. However, the attribute levels of walking time and reservation do not occur the same number of times. The cause of these unbalanced attributes is the unequal number of attribute levels across the attributes. Whereas the attributes supply, travel costs, return location and users do have an even number of attribute levels, walking time and reservation do have three attribute levels. It is assumed that this does not lead to biased results because all attribute levels are included in the choice experiment and the fractional design is orthogonal. The fractional designs used in the experiments are shown in Table 4 and Table 5.

Table 4: Fractional factorial design experiment 1

#	W1	W2	T1	T2	T3	RL1	R1	R2	U1
1	1	0	0	0	1	1	1	0	1
2	0	1	0	1	0	1	1	0	-1
3	1	0	-1	-1	-1	1	1	0	1
4	0	1	1	0	0	1	1	0	-1
5	0	1	-1	-1	-1	-1	-1	-1	1
6	0	1	0	0	1	-1	0	1	1
7	-1	-1	0	1	0	1	-1	-1	1
8	1	0	0	1	0	-1	1	0	1
9	1	0	0	0	1	1	-1	-1	-1
10	1	0	1	0	0	-1	-1	-1	-1
11	-1	-1	-1	-1	-1	-1	1	0	-1
12	-1	-1	0	0	1	-1	1	0	-1
13	1	0	0	1	0	-1	0	1	-1
14	-1	-1	1	0	0	1	0	1	1
15	1	0	1	0	0	-1	1	0	1
16	1	0	-1	-1	-1	1	0	1	-1
Sum	4	0	0	0	0	0	4	0	0

Table 5: Fractional factorial design experiment 2

#	SP1	W1	W2	T1	T2	T3	RL1	R1	R2	U1
1	-1	1	0	0	1	0	-1	1	0	1
2	1	0	1	1	0	0	1	1	0	-1
3	1	0	1	0	1	0	-1	-1	-1	1
4	1	-1	-1	0	1	0	1	1	0	-1
5	-1	-1	-1	0	0	1	1	1	0	1
6	1	1	0	0	0	1	1	-1	-1	1
7	-1	0	1	-1	-1	-1	1	1	0	1
8	1	1	0	-1	-1	-1	1	0	1	1
9	-1	1	0	1	0	0	1	-1	-1	-1
10	1	1	0	0	0	1	-1	1	0	-1
11	1	-1	-1	1	0	0	-1	0	1	1
12	-1	1	0	1	0	0	-1	1	0	1
13	-1	1	0	0	1	0	1	0	1	-1
14	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
15	-1	0	1	0	0	1	-1	0	1	-1
16	1	1	0	-1	-1	-1	-1	1	0	-1
Sum	0	4	0	0	0	0	0	4	0	0

6.1.5 Generation and randomisation of choice sets

One of the approaches to design additional design columns for the generation of the choice sets is the randomization of the profiles (Hensher et al., 2005). A similar approach has also been used by e.g. Bandeira (2018) and Dieten (2015). The randomization has been performed in Excel by using the function "ASELECT". It has been ensured that the choice sets do not contain any dominant alternatives. A choice set with a dominant alternative does not give "any additional information on the relative importance of attributes and are therefore not really informative in the analysis of preferences" (Crabbe & Vandebroek, 2012). Therefore, the profiles have been generated again and again until there were no dominant alternatives in the choice sets anymore. The final choice sets are shown in Table 6 and Table 7.

Table 6: Choice sets experiment 1

Set	Profile	W	T	RL	R	U
1	11	2	3	1	0	1
	9	0	2	0	2	1
2	5	1	3	1	2	0
	2	1	1	0	0	1
3	6	1	2	1	1	0
	12	2	2	1	0	1
4	8	0	1	1	0	0
	4	1	0	0	0	1
5	7	2	1	0	2	0
	3	0	3	0	0	0
6	15	0	0	1	0	0
	13	0	1	1	1	1
7	10	0	0	1	2	1
	1	0	2	0	0	0
8	16	0	3	0	1	1
	14	2	0	0	1	0

Table 7: Choice sets experiment 2

Set	Profile	SP	W	T	RL	R	U
1	5	1	2	2	0	0	0
	11	0	2	0	1	1	0
2	15	1	1	2	1	1	1
	9	1	0	0	0	2	1
3	13	1	0	1	0	1	1
	16	0	0	3	1	0	1
4	12	1	0	0	1	0	0
	14	1	2	3	1	2	1
5	6	0	0	2	0	2	0
	2	0	1	0	0	0	1
6	4	0	2	1	0	0	1
	3	0	1	1	1	2	0
7	1	1	0	1	1	0	0
	8	0	0	3	0	1	0
8	7	1	1	3	0	0	0
	10	0	0	2	1	0	1

Respondents may get bored if they have to fill in a large number of choice sets and may even leave the survey, which leads to undesirable lower response rates. Hensher et al. (2005) noted that "it is an open debate as to how many choice sets is a large number". However, Caussade et al. (2005) investigated the error variance with a specific number of choice situations. They found that stated choice experiments with 9 or 10 choice experiments seem to be optimal in terms of minimising error variance. Nevertheless, they also concluded that the design dimension number of choice scenarios is the least important when considering the number of attributes, alternatives, attribute levels and choice scenarios. Since two choice experiments instead of one experiment are included in the survey, the number of choice scenarios is limited to four per experiment per respondent. Hensher et al. (2005) concluded that the complete randomization of the choice set presentation to each respondent would be ideal. The survey is distributed online, which makes it possible to randomly present some choice sets to the respondent. Accordingly, each respondent has randomly received four out of eight choice sets in both experiments in order to limit the number of questions in the survey and increase the response rate. In addition, the choice decisions made in the choice experiment are not always stable across a sequence of choice sets, because of value and strategic learning (Scheufele & Bennett, 2012). Value learning implies that respondents 'discover' their true underlying preferences throughout the choice experiment, whereas strategic learning means that the respondents become increasingly familiar with strategic opportunities, leading to adjusting their choices (Scheufele & Bennett, 2012). To avoid this possible bias, the choice sets have been displayed in a random sequence.

6.2 Potential effect on car ownership

The choice experiments focus on specific trips, so respondents could think about the intention to use shared modes in realistic choice contexts. Based on that, the respondent is easier able to think about a more difficult decision, the relinquishment of the (least used) car when a mobility hub would be provided in their neighbourhood. Firstly, the respondents have been asked to assess the importance of the availability of the shared modes (shared car, moped, e-bicycle and e-cargo bicycle) in the mobility hub in their choice to relinquish a car. Secondly, the respondents have been asked to assess the importance of the attributes of the mobility hub (walking time, costs, return location, reservation time, known users) in their choice to relinquish a car. Both questions do have a Likert scale: very unimportant up to very important. In this way, the preferable modes and characteristics of people who (may) relinquish a car have been investigated. Finally, the respondents have been asked to indicate whether they would think about relinquishing their (least used) car if their preferred mobility hub would be provided in their neighbourhood. If the respondent is (maybe) not willing to think about relinquishing a car, the reason has been asked.

6.3 Additional questions

The main part of the survey contains the stated choice experiments. Besides, additional questions have been asked to the respondents to:

- Analyse the effect of attitudes, social norm and socio-demographic characteristics on the intention to use the carsharing system/mobility hub and the intention to relinquish the (least used) car (according to the theoretical framework, see chapter 4)
- Route the respondents along the right way throughout the survey
- Show the correct information in the stated choice experiment
- Assess the representativeness of the respondents in the survey

Introduction

Before the start of the survey, the respondents have been faced with an introduction to inform the respondents about the objective, the anonymous use of the data and the maximum time the survey takes. Moreover, the respondents have been informed about the possibility to win a price to stimulate people to fill in the survey and achieve a higher response rate.

Questions before SC experiments

Afterwards, the respondents have filled in information about their postal code, household car ownership, actual travel behaviour and their experience with shared modes. Furthermore, respondents' households owning one or more cars indicated to what extent they agree with various statements focused on attitudes and social norm of the respondents towards car ownership and use of shared modes.

PC6 and household car ownership
The postal code of the residential address has been asked on a PC6-level to determine the neighbourhood and the location of the respondents' dwelling. Postal codes on a PC4-level do often belong to more than one neighbourhood and are unsuitable to determine the residential neighbourhood of the respondent. The respondents' neighbourhood is important to assess whether the respondent lives in one of the selected neighbourhoods of this research. Furthermore, information about the household car ownership and plans to relinquish/buy a car have been asked to route the respondent throughout the survey and to show the respondents the correct information in the stated choice experiments. Also, information about the least used car has been asked (private/lease car, km/year, segment) to identify different perceptions among different distances and car segments. Households with zero vehicles and households with plans to relinquish a car in the upcoming year have been asked to identify the most important reason for this to assess whether the current supply of shared modes influences car ownership-related decisions. Included options are costs, availability of shared modes and accessibility by public transport and bicycle. In the case of a planned reduction in car ownership, additional included answers are changed residential address and changed job circumstances. The latter option is included since life events as employment status and income are among the most likely reasons to change car ownership (Clark et al., 2016).

Actual travel behaviour
Subsequently, information about the actual travel behaviour of the respondent has been asked to indicate the frequency of use of transport modes and their preferred transport mode for different trip purposes. The questions and answer categories are similar to the MPN-data of 2016 (Hoogendoorn-Lanser, Schaap, & Kalter, 2015) in order to assess the representativeness of the sample. Besides, the actual travel behaviour of the respondents has been used as a determinant for the analysis of the potential effect of mobility hubs on household car ownership.

Attitudes & social norm
Statements focused on the attitudes and social norm regarding car ownership and shared modes have been asked to investigate the effect on the intention to use the mobility hub and intention to reduce car ownership, as indicated in the theoretical framework (see chapter 4). Three statements focus on the attitudes of the respondent, whereas the other three statements focus on social norm. The statements about the attitudes measure the extent to which the respondent is attached to car ownership and is (not) willing to use shared modes. The statements about the social norm measure to what extent the respondent is influenced by other people in their travel-related decisions. The sequence of all statements is randomized. The following statements have been included:

- The car gives me freedom.
- I sometimes consider using the bicycle and/or public transport instead of the car
- If shared cars would be available anywhere at any time, I do not need my car
- A car says a lot about someone's social status
- If other people would choose more often for sustainable modes, I would do that as well
- My friends think you should only use the car if needed

Experience with shared modes
In addition to the actual travel behaviour, the experience with shared modes may also influence the intention to relinquish the (least used) car. The experience with shared modes depends on the familiarity with the concept of shared modes and the frequency of using shared modes. The familiarity with shared modes in their neighbourhood and the actual use of shared modes have been asked to identify the respondents' experience with the concept of shared modes. In the case that the respondent makes use of any shared mode, it has been asked to identify these specific shared modes.

Questions after SC experiments

The last part of the survey focuses on socio-demographic characteristics. The socio-demographic characteristics have been asked to investigate the effect of these factors on the intention to use carsharing systems and mobility hub, and the intention to relinquish the (least used) car (see chapter 4). The following socio-demographic characteristics have been asked since they may influence car ownership-related decisions (see section 2.2):

- Gender
- Age
- Educational level
- Household composition
- Household income
- Employment status

Additionally, the socio-demographic characteristics of the respondents have been compared with the inhabitants of the selected neighbourhoods to assess the representativeness. Therefore, the categories of the socio-demographic are similar to the categories included in the data of the Municipality of The Hague (2019). The categories of the socio-demographic characteristics are not randomized since these answers are mainly ordinal. In order to stimulate inhabitants of the investigated neighbourhoods to fill in the survey, the respondents have been asked to fill in their e-mail address so they could win one of the prices.

6.4 Testing the survey

The survey has been tested by a group of respondents and experts before the final distribution of the survey among inhabitants of The Hague. The main purpose of testing the survey was to ensure that the survey is understandable for everyone. In total, 29 respondents reviewed the survey. The group of respondents consisted of a selection of friends, family members, and student colleagues. The group of experts consisted of some experts of Arcadis, as well as experts of the Municipality of The Hague. Consultants Sustainability and Behaviour in Mobility, Martijn Derksen, Guido Hagen and Claudia Snel reviewed the survey as experts of Arcadis. Sven Mittertreiner (policy advisor Urban Development) and Charles Huijts (policy advisor Mobility) reviewed the survey as experts of the Municipality of The Hague.

Main improvements were the clarification of the progress bar, some questions and shortening of the explanation. The progress bar in the test survey did not consider the routing of the respondents. Besides, the progress bar was at the top of the page, which was not clear for everyone. The regular progress bar of Qualtrics could not be improved. Therefore, a new progress bar in HTML-code has been added before the questions of the concerning page.

The questions about plans to buy and relinquish a car did not consider whether the household could also lease a car. Therefore, the formulation of the question has been changed. Besides, the question about the distance travelled per year with the (least used) car focused on the personal distance instead of the total distance of the car. Accordingly, the formulation of the question has been changed as well. Furthermore, the question about the segment of the (least used) car was not clear for the respondents. Therefore, the segment has been replaced by *autoklasse*. The answer options have been changed from segment A up to segment D towards *miniklasse, compacte klasse, compacte middenklasse* and *middenklasse*. Moreover, the introduction before the questions about the preferred transport mode has been shortened to clarify the question and improve readability.

The explanation before both stated choice experiments has been shortened in order to reduce survey fatigue. The most important information in the explanation of the attributes has been underlined. The term *deelwijze* (way of sharing) has been replaced by *gebruikers* (users). Besides, the explanation of the attributes return location, users and supply and the attribute levels of return location and users have been shortened. The question about most important factors to reduce car ownership has been clarified to ensure that the question is about characteristics of the mobility hub. Furthermore, the answer *does not know/does not want to say* has been added to the question about annual household income.

The final questions in the survey are included in Appendix B3.

6.5 Data collection

The survey has been conducted in a selection of neighbourhoods in The Hague. This section focuses on the reasons for choosing the selected neighbourhoods, the way the representativeness of the sample has been ensured and the distribution of the survey.

Selection of neighbourhoods

As discussed in the scope of this research (section 3.3), this research specifically focuses on neighbourhoods with an above-average household car ownership (≥ 0.65 cars/household). These neighbourhoods, their level of household car ownership and distance to shared cars are depicted in Figure 19. Parking problems are most relevant in residential areas with high parking pressures (≥ 80% in parts of the neighbourhood). Therefore, selected neighbourhoods should have relatively high parking pressures as well. In order to investigate to what extent the perceptions of residents differ between neighbourhoods with a different supply of shared modes, two areas with a different proximity to shared cars have been selected. Neighbourhoods with a relatively high share of dwellings within 100, 200 and 500 meters of a shared car and neighbourhoods with a relatively low share of dwellings within these distances of a shared car have been selected.

The inner-city neighbourhoods *Geuzen- en Statenkwartier*, *Bomen- en Bloemenbuurt* and *Vruchtenbuurt* do have a relatively high share of dwellings within 100, 200 and 500 meters of a shared car. Additionally, these neighbourhoods have an above-average level of household car ownership (0.7-0.8 cars/household), relatively high parking pressure and are located close to public transport connections. In contrary, the VINEX-neighbourhoods *Ypenburg* and *Leidschenveen* do have lower shares of dwellings within the proximity of a shared car. These neighbourhoods have a relatively high level of household car ownership (1.1-1.2 cars/household) and a relatively high parking pressure. Besides, there is a wide variety of public transport options available, despite these neighbourhoods are located near the national highway. It should be noted that the selected neighbourhoods differ in built environment characteristics. The inner-city neighbourhoods are denser populated areas and located closer to the city centre, compared to the VINEX-neighbourhoods.

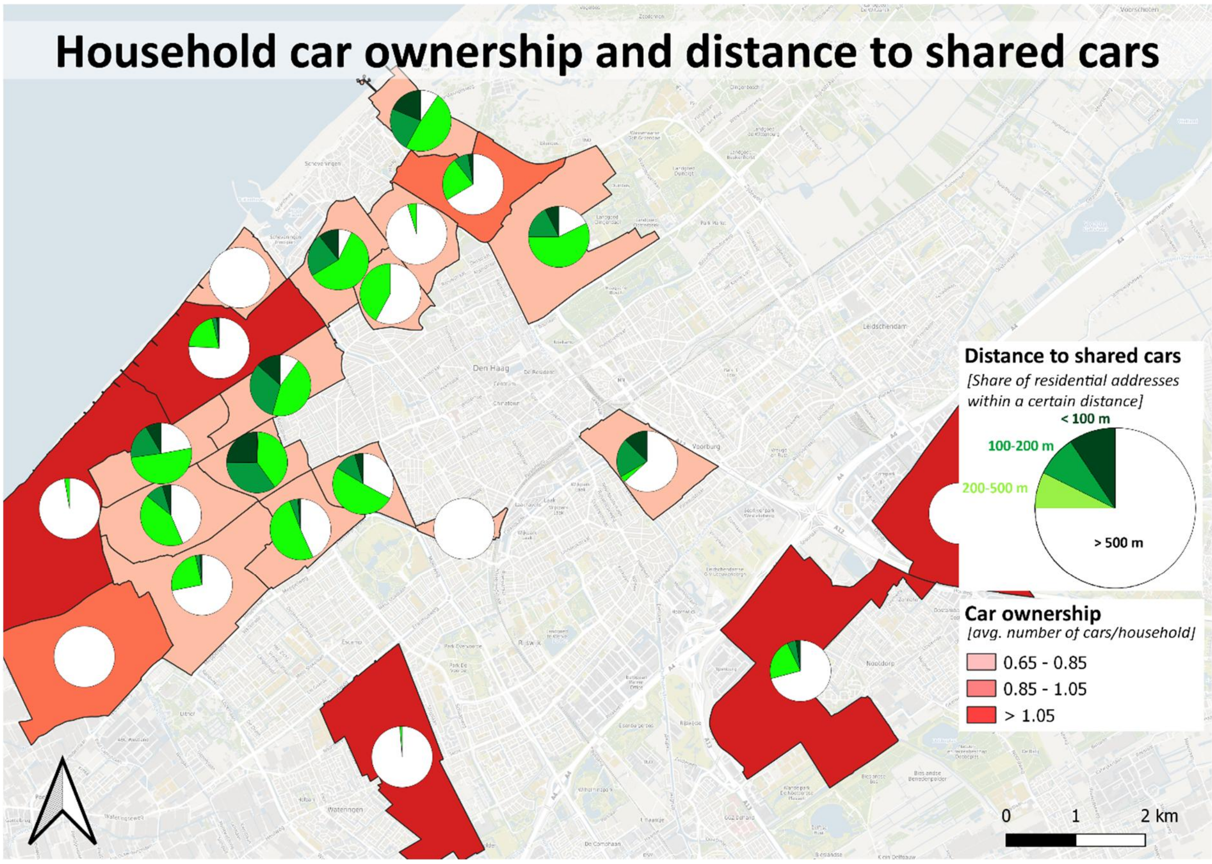

Figure 19: Household car ownership and distance to shared cars

Representativeness of sample

The socio-demographic characteristics of the sample of the survey have been compared with the characteristics of the population of the concerning neighbourhoods in order to assess the representativeness of the sample (see section 7.1). Data of the Municipality of The Hague (2019) have been used, which contains information about the gender, age, educational level, household composition and household income of all inhabitants of the concerning neighbourhoods.

The minimum required response size with a population size *N* can be calculated by using the following formula (Survey Monkey, 2019):

$$n = \frac{\frac{z^2 \cdot p(1-p)}{m^2}}{1 + \frac{z^2 \cdot p(1-p)}{m^2 N}} \tag{6.1}$$

Here, *n* is the number of required respondents, *z* is the z-score related to the confidence interval, *p* is the standard deviation, *m* is the margin of error and *N* is the population size. The required sample sizes for the investigated neighbourhoods can be found in Table 8 (*p*=0.5, *m*=0.05).

Table 8: Neighbourhood information with the required sample size in the case of 95% (z=1.96) and 90% (z=1.65) confidence interval

Neighbourhood	**# households** (Municipality of The Hague, 2019)	**Minimum sample size** (95% confidence int.)	(90% confidence interval)
Sample A - Geuzen- en Statenkwartier - Bomen- en Bloemenbuurt - Vruchtenbuurt	18,814 (6,690) (7,554) (4,570)	377	269
Sample B - Ypenburg - Leidschenveen	17,858 (10,231) (7,627)	377	269

Distribution

The survey has been distributed by sending letters to residential addresses in the selected neighbourhoods in The Hague. Since the survey should be filled in on the internet due to the randomisation of the choice sets, a reference to the website of the survey has been included in the letter. The selection of residential addresses has been based on several criteria. The purpose of this study is to investigate the potential effect of mobility hubs on car ownership. Therefore, households with at least one car are selected for the distribution. The selection of residential addresses is random, which results in a higher distribution rate in the neighbourhoods with a higher number of households. To investigate whether there are differences between the two type of neighbourhoods, 50% of the total number of letters have been sent in each neighbourhood type. The expected response rate is 5-10%. Therefore, 12,000 letters have been distributed.

6.6 Survey analysis

This section shows how the survey analysis has been performed. First of all, the data selection and preparation, descriptive statistics and statistical analysis are discussed. Subsequently, the random utility theory and different logit models, which are used for the analysis of the stated choice experiments, are discussed. After that, the model specifications, the model analysis and the scenarios are discussed. The data selection, descriptive statistics and statistical analyses have been performed by using SPSS (IBM Corp., 2017). The data preparation has been performed in SPSS, Excel and Notepad++. The model specification has been defined in Notepad++, whereas the model estimation has been performed by using BIOGEME (M. Bierlaire, 2018). The different steps of the survey analysis are separately discussed below.

6.6.1 Data selection and preparation

Before the descriptive statistics, statistical analysis and model analysis, the appropriate data should be selected and prepared. The following actions have been performed:

1. Delete unfinished surveys
2. Add neighbourhood and sample information
3. Delete surveys with postal code outside the research area
4. Dummy coding for model estimation

Data selection

Unfinished surveys have been deleted. Since the objective of this research is to investigate the potential effect of a mobility hub on car ownership, respondents must have finished the survey up to the question regarding this effect. Accordingly, the survey should be completed up to 96%. However, a relatively small group of respondents (N=12, 1.0%) completed the survey for 96%. The socio-demographic characteristics of this group are unknown, which makes the assessment of the representativeness of the sample and the model analysis more complicated. Therefore, only complete surveys (N=1187) have been used. Afterwards, additional information of the neighbourhood and sample (A or B) has been added to the survey results by matching the postal code of the respondent by the postal codes belonging to the different investigated neighbourhoods and samples. Surveys with a postal code outside both research areas have been removed. Finally, 1,174 complete surveys are considered in this research: 583 respondents in sample A and 591 respondents in sample B.

Data preparation

Subsequently, the data of the choice experiments is dummy coded for the estimation of the models in BIOGEME (see Table 9). The dummy coded data includes the respondent ID, the system (and mode) choice and the system/mobility hub characteristics of both provided alternatives in the choice set. Besides, the data of the trip and socio-demographic characteristics are dummy coded as well. In the case of Mixed logit models, the data is sorted by order of the respondent's ID rather than per choice set.

Table 9: Example of dummy coded data in Notepad++

RID	Choice	Avail	SA_WT_3	SA_WT_6	SA_WT9	SA_TC_50	SA_TC_40	SA_TC_30	SA_TC_20	…
8	3	1	0	0	1	1	0	0	0	…
9	3	1	0	0	1	1	0	0	0	…
11	2	1	0	0	1	1	0	0	0	…
…	…	…	…	…	…	…	…	…	…	…

6.6.2 Descriptive statistics & statistical analysis

After the data selection and preparation, the survey data have been analysed by using descriptive statistics and statistical techniques. Both methods are separately discussed below.

Descriptive statistics

The descriptive statistics of the data describe and summarize the collected values of the variables. The descriptive statistics provide insight into the location (mean, median, mode), variability (standard deviation, range) and the skewness of the data (Schuberth, 2018). The descriptive statistics could indicate relevant relationships between answers in different questions. Besides, the characteristics of the sample have been compared to the characteristics of the population to assess the representativeness of the sample.

Statistical techniques

Although descriptive statistics provide insight into general information of the dataset, it does not provide statistical evidence. Statistical techniques have been used for the analysis of the survey data. The Chi-square test has been performed to investigate associations between two variables. The Chi-square measures how much the observed cell counts differ from the expected cell counts in a cross table with two variables (Moore, McCabe, & Craig, 2009). The null hypothesis is that there is no association between two variables, whereas the alternative hypothesis is that there is an association between the variables. If the null hypothesis is true, the Chi-square statistic has approximately a Chi-square distribution with (r-1)(c-1) degrees of freedom. Large values of the Chi-square statistic show that observed and expected values are very different, which provides evidence against the null hypothesis. If the p-value is lower than or equal to the significance level, the variables are statistically significantly associated, and the null hypothesis can be rejected.

Although the Chi-square test can be used to investigate whether there is an association between two variables, it does not say anything about the direction of the association. Correlation analysis has been used to examine the direction and strength of the linear relationship between two variables (Moore et al., 2009). Pearson correlation, Spearman's rho and Kendall's tau-b are the most used correlation tests (Statistics Solutions, 2020). The Kendall's tau-b correlation test has been used because it is specifically suitable for variables measured on an ordinal scale (Magiya, 2019). The strength of the correlation depends on the correlation coefficient. Coefficients of 0.50 and higher represent a large association, coefficients between 0.30 and 0.50 represent a moderate association, while coefficients smaller than 0.30 represent a small association (Statistics Solutions, 2020).

6.6.3 Random utility theory

Random utility or discrete choice models model the choice of a decision-maker among a set of alternatives (Walker & Ben-Akiva, 2002). In these models, it is assumed that everyone maximises utility, i.e. chooses the alternative with the highest (perceived) utility (Train, 2009). The utility of an alternative captures all factors of concern so that the overall goal is to maximise the utility. The probability that decision-maker *n* chooses alternative *i* can be expressed as:

$$P_{ni} = Prob\left(U_{ni} > U_{nj}\ \forall\ j \neq i\right) \tag{6.2}$$

Utility theory

The utility of the alternatives is known to the decision-maker. However, the researcher only knows the preference indicators, which are representations of the unobserved underlying utilities (Walker & Ben-Akiva, 2002). The utility of an alternative can be decomposed into a systematic utility (V_i) and an unobserved random utility (ε_i) (Train, 2009). The systematic utility includes all parameters that are unknown to the researcher and are statistically estimated. In turn, the random utility covers the parameters that affect utility but are not included in the systematic utility. The random utility is a vector of disturbances and is usually defined as the difference between the true utility and the perceived utility (Train, 2009; Walker & Ben-Akiva, 2002). The utility of alternative *i* can be expressed as:

$$U_i = V_i + \varepsilon_i \tag{6.3}$$

The systematic utility can be further composed into an alternative-specific constant (ASC_i) and attributes ($x_{i,j}$), which are statistically estimated. The alternative-specific constant captures the impact of all factors that are not included in the model (Train, 2009). The included attributes can contain both attributes of the alternative and the decision-maker. The systematic utility of alternative *i* can be expressed as:

$$V_i = ASC_i + \sum_{j=1}^{J} \beta_{i,j} \cdot x_{i,j} \tag{6.4}$$

"The absolute level of utility is irrelevant to both the decision-maker's behavior and the researcher's model." (Train, 2009). Since only the differences in utility matter, the alternative-specific constant (ASC) of one of the alternatives is fixed to zero. The values for β show the effect of the attribute on the utility. A larger value of β means that the attribute as a larger effect on the utility of the specific alternative. The alternative-specific constant (ASC_i) and the coefficients of the attributes ($\beta_{i,j}$) are statistically estimated.

Logit models

The coefficients of the attributes can be estimated by using logit models. Different logit models can be distinguished among which the Binary, Multinomial, Nested, Cross-nested and Mixed logit model. The Binary logit and the Multinomial logit (MNL) model assume that the random variable is independent and identical Gumbel distributed and that there is no correlation among alternatives (IIA-property) (Train, 2009). The only difference between both models is the number of distinguished alternatives. Whereas the binary logit distinguishes two alternatives, the multinomial logit model distinguishes three or more alternatives. The probability of choosing an alternative over the other alternative(s) can be calculated by applying the following formula (Train, 2009):

$$P_i = \frac{e^{V_i}}{\sum_{j=1}^{J} e^{V_j}} \tag{6.5}$$

While the two previously discussed models assume that the alternatives are independent of each other, the Nested and Cross-nested logit model allow for correlation between two or more alternatives (Train, 2009). The correlated alternatives are grouped within a nest. The IIA-property (if one alternative is removed, the probability of the others will increase) holds only within nests, but not across nests. The Cross-nested model has the property that an alternative can belong to more than one nest. The last model discussed is the Mixed logit (ML) model, which can be distinguished into a random coefficients model and an error components model. The ML model with random coefficients allows for random taste variation (Puello, 2019). Hereby, the coefficients of the attributes ($\beta_{i,j}$) follow a distribution. On the other hand, the ML model with error components covers the unrestricted IIA property and correlation in unobserved factors over time (panel effects) by adding an extra error component to the utility function(s). Thus, the latter model is suitable to incorporate the correlation in unobserved factors over time among the respondents.

6.6.4 Model specification

Each alternative has a systematic utility, which consists of an alternative-specific constant and the coefficients of the attributes, as discussed in the random utility theory (see section 6.6.3). The value of x_j represents the value of the attribute level. The effects of walking time and travel costs have been included as linear attributes. All other attribute values have been dummy coded in the final models. Accordingly, one of the categories has been excluded from the model specification. For instance, a reservation obligation has been included in the utility functions. A zero for the attribute level represents no reservation obligation, whereas a one represents reservation obligation. The model specifications for the MNL models are clarified in Table 10, the attribute levels are clarified in Table 11. An additional error component or random term ζ_i should be added to the model specifications of the concerning alternatives in the Mixed logit models with error components. This random term is assumed to be normally distributed: $\zeta_i \sim N(m_i, \sigma_i^2)$. The mean m_i is fixed to zero, the standard deviation σ_i has been estimated.

Table 10: Model specifications

#	Model specification
1	Preferred carsharing systems
	$V_{carsharingsystem} = ASC_{system} + \sum_{j=1}^{J} \beta_j \cdot x_j$ (6.6) $V_{none} = ASC_2 = 0$ (6.7)
2	Intention to use the shared car of preferred carsharing systems
	$V_{shared\ car} = ASC_{shared\ car} + \sum_{j=1}^{J} \beta_j \cdot x_j$ (6.8) $V_{own\ car} = ASC_1 = 0$ (6.9)
3	Preferred mobility hubs
	$V_{mobilityhub} = ASC_{hub} + \sum_{j=1}^{J} \beta_j \cdot x_j$ (6.10) $V_{none} = ASC_2 = 0$ (6.11)
4	Intention to use shared modes of preferred mobility hubs
	$V_i = ASC_i + \sum_{j=1}^{J} \beta_{i,j} \cdot x_{i,j} \ where\ i = \begin{cases} 2 & shared\ car \\ 3 & shared\ moped \\ 4 & shared\ ebicycle \\ 5 & shared\ ecargo\ bicycle \end{cases}$ (6.12) $V_{own\ car} = ASC_1 = 0$ (6.13)

The meaning of the parameters representing the system or mobility hub characteristics that have been used in these model specifications are explained in Table 11. Additionally, the attribute levels of these parameters and the models to which the parameters belong are clarified. It should be noted that also other characteristics (trip, socio-demographic characteristics and statements about attitudes and social norm) are included in the final model specifications.

Table 11: Explanation of the meaning of parameters belonging to the specific system (1 & 2) or mobility hub (3 & 4)

Parameter	Meaning (attribute levels)	1 & 2	3 & 4
$\beta_{travel\ costs}$	Travel costs of shared car (0 = €0.20/km, 1 = €0.30/km, 2 = €0.40/km, 3 = €0.50/km)	+	
$\beta_{travel\ costs\ OM}$	Travel costs of moped, e-bicycle and e-cargo bicycle (0 = €0.40/km, 1 = €0.30/km, 2 = €0.20/km, 3 = €0.10/km) Note: costs of shared car are fixed at €0.40/km		+
$\beta_{walking\ time}$	Walking time (0 = 3 min, 1 = 6 min, 2 = 9 min)	+	+
$\beta_{reservation}$	0 = No reservation needed 1 = Reservation obligation (30 or 60 minutes)	+	+
$\beta_{known\ users}$	0 = Sharing with known and unknown users 1 = Only sharing with known users	+	+
$\beta_{no\ return\ needed}$	0 = Return to pick-up point 1 = No return to pick-up point needed	+	+
$\beta_{shared\ car}$	0 = Shared car is not provided in the mobility hub 1 = Shared car is provided in the mobility hub		+

6.6.5 Model analysis

The MNL and ML model with error components have been used in this research. After exploring the best MNL model, ML models with error components have been used as well to find the best models. The model analysis started with only alternative specific constants in the utility functions of the different alternatives. Subsequently, the attributes are added one by one to assess whether the model is improving. System, trip, socio-demographic characteristics and statements regarding attitudes and social norm have been added successively.

Logically, the attributes in the different utility functions in a model do not need to be the same (Hensher et al., 2005), since the utility of an alternative may be defined by different attributes. The results provide a value for every attribute in the utility function, as well as a p-value. A p-value of less than 0.05 indicates that the explanatory variable is statistically significant, assuming a 95% confidence interval (Hensher et al., 2005). When a variable is insignificant, the insignificant variable has been removed and the model has been re-estimated, as is common practice (Hensher et al., 2005). Whether a model is improving compared with the former estimated models has been tested by using the Likelihood ratio test (see below). The final model is a model which cannot be improved by adding more (significant estimated) variables. The correlation between the included parameters in the final models has been checked to avoid the inclusion of two highly correlated variables.

The estimation of ML models has been done by simulation. Hensher et al. (2005) noted that the best test is to estimate the models over a range of draws. Therefore, the ML models have been tested over a range of 20, 50, 100, 500 and 1000 draws, dependent on the stability of the model parameters and their significance level. The simulation of ML models has been started with a relatively small number of draws (20). In this way, the alternative model specifications have been explored relatively quickly.

The goodness of fit & model assessment

The rho-squared and adjusted rho squared have been used to assess the model fit. The Likelihood ratio test has been performed to assess whether a model with more parameters is improving compared to a model with fewer parameters. Accordingly, the Likelihood ratio test has been used to identify the best model. Both model fits and the Likelihood ratio test have been shortly discussed below.

The rho-squared (or likelihood ratio index) is often used to measure how well a model fits the data in comparison with a model in which all parameters are zero (Train, 2009). The value of rho-squared is between 0 and 1. If the estimated parameters in a model do not perform better than a model with zero parameters, the rho-squared is equal to 0 (Train, 2009). If the estimated parameters in a model perfectly model each decision maker's choice, the rho-squared is equal to 1. Regarding studies in the transport sector, models with a rho-squared between 0.2 and 0.4 are considered as good fits (Hensher et al., 2005). The rho-square is defined as:

$$\rho^2 = 1 - \frac{LL(\hat{\beta})}{LL(0)} \tag{6.14}$$

The rho-squared value never decreases when adding more parameters to the model. The adjusted rho-squared also considers the number of parameters (*k*) included in the model. The value of the adjusted rho-squared is always lower than or equal to the value of the rho-squared. The adjusted rho-squared is defined as:

$$\bar{\rho}^2 = 1 - \frac{LL(\hat{\beta}) - k}{LL(0)} \tag{6.15}$$

The Likelihood ratio test has been used to assess whether a model is improving based on the number of parameters and log-likelihood (Michel Bierlaire, 2017; Train, 2009). The model with more parameters leads to better estimation results when the log-likelihood ratio (LL-ratio) multiplied by -2 is larger than the value from the Chi-square table:

$$-2(LL_{restricted} - LL_{unrestricted}) > \chi^2(K_{unrestricted} - K_{restricted}) \tag{6.16}$$

The LL-ratio is calculated by using the log-likelihood of the more restricted ($LL_{restricted}$) and less restricted ($LL_{unrestricted}$) model. The number of degrees of freedom of the Chi-square value is based on the number of free coefficients (K) of both the unrestricted and restricted model. A model is more unrestricted when it has a higher number of free coefficients than the other model. In turn, the other model is more restricted. So, a model with only an alternative specific constant and zero attributes (or free coefficients) is the most restricted model.

6.6.6 Scenarios

Based on the estimated parameters in the final ML models (see section 7.3.1 and 7.3.2), the intention to use shared modes can be calculated for specific scenarios. The scenarios can differ in system, trip, socio-demographic characteristics, attitudes, and social norm. The probability of choosing a mobility hub has been calculated by considering the choice between the preferred mobility hub (with specific characteristics) and the option "None". The probability for having the intention to use a shared mode has been calculated by multiplying the probability of choosing the mobility hub with the probability of choosing the concerning shared mode:

$$P_{shared\ mode} = P_{mobilityhub}\ x\ P_{shared\ mode|mobilityhub} \tag{6.17}$$

The probability of choosing the own car can be calculated by applying the following formula:

$$P_{own\ car} = 1 - \sum\nolimits_{i=1}^{I} P_{shared\ mode,i} \tag{6.18}$$

It should be noted that by using this multiplication it is assumed that everyone who chooses none of the mobility hubs, does prefer the own car. However, it might be the case that the respondent experiences an equally high utility for both mobility hubs, which causes difficulty of choosing a preferred mobility hub. As a result, the respondent might choose for "None" instead of one of the advantageous mobility hubs. It is assumed that this does not lead to significantly different results. However, the actual intention to use shared modes might be higher.

The probability of choosing the mobility hub and the probability of choosing a shared mode, given the mobility hub is preferred can be calculated by applying formula 6.5. The system utility depends on the parameter values of the final estimated ML models (see section 7.3.1 and 7.3.2). All error terms for panel effects have been drawn 10,000 times to get more robust results. The distribution of the error term has been checked and follows a normal distribution. This implies that the number of draws is reasonably fair. Subsequently, corresponding probabilities have been calculated. The average probability of all these draws have been used in formula 6.17 in order to calculate the probability of choosing a specific shared mode.

6.6.7 Analysis of household car ownership

The analysis of the potential effect of mobility hubs on household car ownership has been investigated among all households, households without planned reductions and households without (perhaps) planned reductions. By excluding households with (perhaps) planned reductions in households, the potential effect of mobility hubs can be better assessed. Furthermore, the unobserved effect of households who refrain from buying a car has been considered by including these households. The association between variables and the intention to reduce household car ownership has been investigated by the statistical analysis techniques discussed in section 6.6.2. The used method of exploring association between the intention to use and intention to reduce household car ownership needs more explanation and is discussed below.

Association between intention to use & intention to reduce household car ownership

The association between the intention to use and the intention to reduce household car ownership has been investigated by comparing the distributions of the utilities across the categories of the intention to reduce household car ownership (no, maybe, yes). Here, both the average utility of the preferred alternatives and all presented alternatives have been explored.

The results of the models of preferred mobility hubs (section 7.3.1) are used for the calculation of the utilities of the alternatives presented to the respondents. The error term for panel effects has been drawn twenty times to get more robust results. Consequently, the average utilities of the preferred alternatives and all alternatives are calculated twenty times for every respondent. The average utility of the preferred alternatives is based on the answers of the respondent (Mobility hub A, Mobility hub B, None) across the four choice sets *s*. This average utility can be calculated by applying the following formula:

$$\bar{V}_{utility\ of\ preferred\ alternatives} = \frac{1}{4}\sum_{s=1}^{s=4} V_{preferred\ alternative,s} \quad (6.19)$$

The average utility of all alternatives is based on the utility of all alternatives in the four presented choice sets to every respondent and can be calculated by applying the following formula:

$$\bar{V}_{utility\ of\ all\ alternatives} = \frac{1}{4}\sum_{s=1}^{s=4} \frac{V_{Mobility\ hub\ A,s} + V_{Mobility\ hub\ B,s} + V_{None,s}}{3} \quad (6.20)$$

By using the average utilities of the preferred and all alternatives of the twenty draws of every respondent, the mean and standard deviation in the mean have been calculated for the three categories (no, maybe, yes). Subsequently, the average utilities are separately ordered and classified into intervals for the preferred and all alternatives. This is also separately performed for the three categories of the intention to reduce household car ownership (no, maybe, yes). Only intervals including at least 20 observations in both samples are investigated to achieve more robust results. The probability of the intention to reduce household car ownership *r* in a specific interval *i* is based on the number of observations *N* of the concerning intention divided by the total number of observations in the specific interval *i*, according to the following formula:

$$P_{r,i} = \frac{N_{r,i}}{N_i} \qquad if\ \ N_{u,i} \geq 20 \quad (6.21)$$

Formula 6.21 applies to both the average utility of the preferred alternatives as well as the average utility of all alternatives.

7 Results

This chapter presents the survey results. The representativeness of the sample is discussed with regard to the socio-demographic characteristics, frequency of transport mode use and preferred transport mode use for different trip purposes is discussed. Additionally, the results of the descriptive analysis are presented. Furthermore, the model results aimed at investigating preferred carsharing systems and mobility hubs and the intention to use shared modes provided by these systems are presented. Finally, the intention to reduce household car ownership and the most important shared modes and factors to reduce household car ownership are discussed. This chapter contains the results of the main research question:

What characteristics influence the intention to use shared modes provided by mobility hubs and what is the potential effect of mobility hubs on household car ownership?

In total, data of 1174 respondents are considered in this analysis. These respondents have their dwelling in one of the neighbourhoods in the research area (see Table 12). Households in the neighbourhoods *Geuzen- en Statenkwartier*, *Bomen- en Bloemenbuurt* and *Vruchtenbuurt* are referred to as **sample A** (SA). Households in the neighbourhoods *Ypenburg* and *Leidschenveen* are referred to as **sample B** (SB). All households in these neighbourhoods together are referred to as **sample**. The total population in the neighbourhoods of sample A is referred to as population A, whereas the total population in the neighbourhoods of sample B is referred to as population B. The total population in all these neighbourhoods together is referred to population.

Table 12: Sample description

<table>
<tr><th>Neighbourhood</th><th>N</th><th>%</th><th colspan="2">Sample description</th><th colspan="2">Population description</th></tr>
<tr><td>Geuzen- en Statenkwartier</td><td>200</td><td>17.0</td><td rowspan="3">Sample A (N=583)</td><td rowspan="5">Sample (N=1174)</td><td rowspan="3">Population A</td><td rowspan="5">Population</td></tr>
<tr><td>Bomen- en Bloemenbuurt</td><td>246</td><td>21.0</td></tr>
<tr><td>Vruchtenbuurt</td><td>137</td><td>11.7</td></tr>
<tr><td>Ypenburg</td><td>339</td><td>28.9</td><td rowspan="2">Sample B (N=591)</td><td rowspan="2">Population B</td></tr>
<tr><td>Leidschenveen</td><td>252</td><td>21.5</td></tr>
</table>

7.1 Representativeness of sample

This section discusses the representativeness of the sample regarding the socio-demographic characteristics, the frequency of transport mode use and preferred transport mode for different trip purposes.

Socio-demographic characteristics

Table 13 shows a comparison of the socio-demographic characteristics of the sample and the population of the investigated neighbourhoods. It should be noted that the survey has been distributed among households with at least one car. Therefore, households with at least one car are overrepresented in comparison with the population. More men than women completed the survey, inherent to the higher levels of car ownership among men (CBS, 2016). Besides, previous research showed that men are more likely to adopt for carsharing (Becker et al., 2017; Kopp et al., 2013; Prieto et al., 2017). Consequently, they could be more interested in the topic of this research and more likely to complete the survey. Additionally, people younger than 20 years are underrepresented, whereas the groups 45-65 years and 65-80 years are overrepresented in both samples. Since this survey has been addressed to the inhabitants of specific addresses and focuses on the household level as well, it is more likely that parents as head of the household completed the survey instead of younger people. Elderly people (≥ 80 years) are slightly overrepresented in sample B, whereas this group is slightly underrepresented in sample A. Furthermore, higher-educated people are overrepresented in both samples. Higher educational levels are positively associated with car ownership (PBL, 2008). Besides, Prieto et al. (2017) concluded that higher educated people are more likely to adopt for carsharing, which may result in a higher response rate, since these people may be more interested in the subject.

Additionally, people living together (with or without children) are overrepresented in both samples, whereas single-parent households/families are underrepresented. Oakil et al. (2016) concluded that households with two parents are more likely to own a car. Besides, single-parent households/families may have less time to complete the survey. Households with a yearly income of more than € 58,200 are overrepresented, whereas the lower-income households are underrepresented. However, a relatively large proportion of the respondents indicated that he/she does not know or want to say the yearly household income. So, it could be that the lower-income groups have indicated this more often. Besides, higher household incomes are associated with a higher level of car ownership (CBS, 2016). Concerning the employment status, relatively more people in sample A are working independently in comparison with sample B. Similarly, relatively more people are retired in sample A. On the other hand, relatively more people in sample B are working as an employee. The explanation for the differences in the proportion of retired people in sample A is inherent to the proportion of elderly in the population.

Table 13: Comparison of socio-demographic characteristics sample & population

	Sample (N=1174)		Population		Sample A (N=583)		Population A		Sample B (N=591)		Population B	
Characteristic	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Gender												
Male	737	62.8	42333	48.7	362	62.1	18190	47.1	375	63.5	24143	50.0
Female	437	37.2	44579	51.3	221	37.9	20394	52.9	216	36.5	24185	50.0
Age												
< 20 years	12	1.0	23743	27.3	4	0.7	8655	22.4	8	1.4	15088	31.2
20-45 years	306	26.1	26024	29.9	143	24.5	11668	30.2	163	27.6	14356	29.7
45-65 years	574	48.9	25951	29.9	252	43.2	11021	28.6	322	54.5	14930	30.9
65-80 years	252	21.5	8779	10.1	167	28.6	5435	14.1	85	14.4	3344	6.9
≥ 80 years	30	2.6	2415	2.8	17	2.9	1805	4.7	13	2.2	610	1.3
Educational level												
Low	46	3.9		22.8	17	2.9		16.7	29	4.9		27.7
Middle	247	21.0		36.5	105	18.0		32.9	142	24.0		39.3
High	881	75.0		40.7	461	79.1		50.4	420	71.1		32.9
Household composition												
Single-parent household	179	15.2	11820	32.2	131	22.5	7967	42.3	48	8.1	3853	21.6
Together without children	398	33.9	8949	24.4	218	37.4	4923	26.2	180	30.5	4026	22.5
Together with children	522	44.5	12481	34.0	197	33.8	4485	23.8	325	55.0	7996	44.8
Single-parent family	75	6.4	3422	9.3	37	6.3	1439	7.6	38	6.4	1983	11.1
Household income												
< € 20,600	36	3.1	4519	13.1	18	3.1	2763	15.6	18	3.0	1756	10.5
€ 20,600 – € 29,600	61	5.2	5076	14.8	38	6.5	2953	16.7	23	3.9	2123	12.7
€ 29,600 – € 41,600	180	15.3	6452	18.8	102	17.5	3759	21.2	78	13.2	2693	16.1
€ 41,600 – € 58,200	185	15.8	7172	20.8	91	15.6	3416	19.3	94	15.9	3756	22.5
≥ € 58,200	427	36.4	11189	32.5	191	32.8	4825	27.2	236	39.9	6364	38.1
Do not know / want to say	285	24.3	N/A	N/A	143	24.5	N/A	N/A	142	24.0	N/A	N/A
Employment status												
Working as an employee	687	58.5			283	48.5			404	68.4		
Working independently	159	13.5			97	16.6			62	10.5		
Jobless	36	3.1			18	3.1			18	3.0		
Student	15	1.3			6	1.0			9	1.5		
Volunteer	14	1.2			7	1.2			7	1.2		
Retired	263	22.4			172	29.5			91	15.4		

Frequency of transport mode use

Figure 20 and Figure 21 show the frequency of transport mode use of residents of both samples compared to the average of residents of areas with similar urbanity levels in the Netherlands. Here, only residents with at least one car in their household are considered. The patterns are generally the same, which indicates that the sample of the survey shows similar behaviour as neighbourhoods with similar urbanity levels. However, there are some differences. For instance, residents in sample A use the car less often and the BTM, bicycle and walking more often compared to the average of very densely populated areas in the Netherlands. Besides, residents in sample B more often use the car and BTM and they less often use the bicycle and walking, compared to the average of densely populated areas. This may be explained by the location near the highway, further away from the city centre, and a high-quality network of public transport.

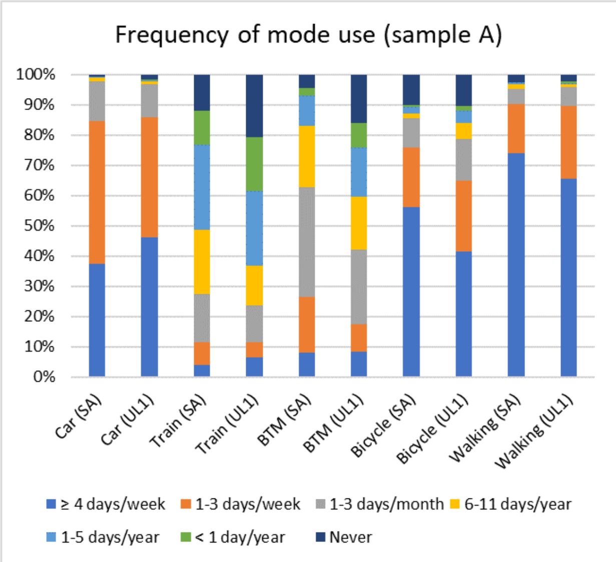

Figure 20: Frequency of mode use of residents of sample A (SA, N=570) and residents of very densely populated areas in the Netherlands (UL1, N=712) based on MPN-data of 2016 (KiM, 2016a). Only residents with ≥1 car/household are considered.

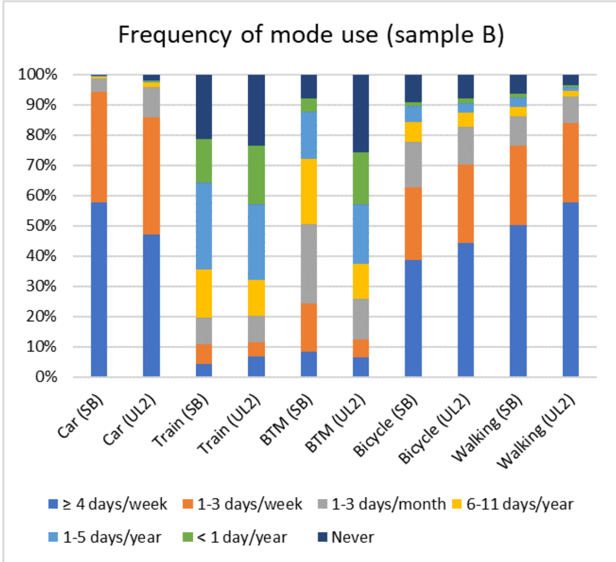

Figure 21: Frequency of mode use of residents of sample B (SB, N=590) and residents of densely populated areas in the Netherlands (UL2, N=1800) based on MPN-data of 2016 (KiM, 2016a). Only residents with ≥1 car/household are considered.

Preferred transport mode

Figure 22 and Figure 23 show the preferred mode choice for different trip purposes of sample A and B compared with the average of residents of areas with similar urbanity levels in the Netherlands. The patterns are similar, indicating that the respondents of the samples do have approximately similar preferences, compared to residents of very densely populated areas (sample A) and densely populated areas (sample B) in the Netherlands. Again, there are some differences. For instance, residents of sample A have a higher preference towards the bicycle and a lower preference towards the car for commuting, school/study and visiting trips. In addition, they more often prefer walking instead of car trips for daily groceries. Concerning shopping trips, they have a higher preference for BTM, rather than the car. Regarding sample B, residents have a higher preference for the car for daily groceries. Besides, they have a higher preference for BTM rather than the bicycle in the case of shopping trips. Moreover, residents of sample B prefer the car rather than the bicycle for visiting people. Besides, residents of both samples have a higher preference towards the train and a lower preference towards the car for business trips.

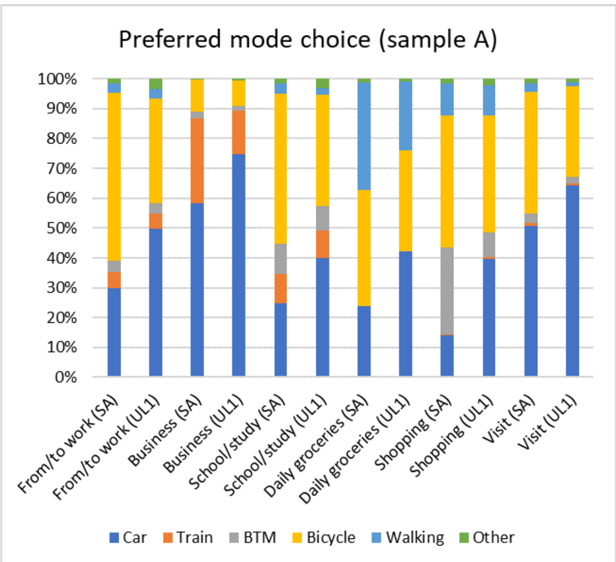

Figure 22: Preferred mode for trip purposes sample A (SA, N=570) and people in very densely populated areas in the Netherlands (UL1, N=713) based on MPN-data of 2016 (KiM, 2016a). Only residents with ≥1 car/household are considered.

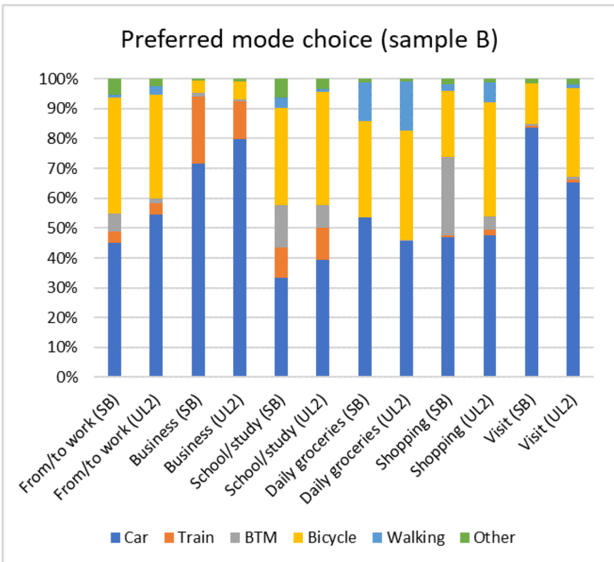

Figure 23: Preferred mode for trip purposes sample B (SB, N=590) and people in densely populated areas in the Netherlands (UL2, N=1801) based on MPN-data of 2016 (KiM, 2016a). Only residents with ≥1 car/household are considered.

7.2 Descriptive analysis

This section describes the descriptive statistics of the survey results. Household car ownership, the use of shared modes, attitudes and social norm are discussed regarding sample A and B.

7.2.1 Household car ownership

Most of the households in sample A and B have one car in their household (see Figure 24). Households in sample B more often have two cars in their household compared to sample A, as expected, since the average level of household car ownership is larger in the VINEX-neighbourhoods of The Hague (Municipality of The Hague, 2019). The Chi-square test shows that the level of household car ownership is significantly larger in sample B compared to sample A (χ^2=87.979, p=0.000, df=3). Concerning households with at least one car, most households do not have plans to change their level of car ownership (see Figure 25). The proportion of households that has plans to relinquish a car is approximately as large as the households with plans to buy a car within one year. Besides, 15.6% of the households in sample A and 12.0% of the households in sample B have plans to perhaps relinquish a car in the upcoming year. Among the households that have currently plans to relinquish the car, the availability of shared modes is (one of) the reason(s) for 33.3% of the households in sample A and 8.7% of the households in sample B. Additionally, almost all (least used) vehicles owned by the households are bought by the respondent or someone else in their household: 94.6% in sample A and 90% in sample B. The yearly distance of the (least used) car in the households is depicted in Figure 26. Logically, households with more cars drive less distance with their least used car (< 5,000 km/year) compared to households owning one car.

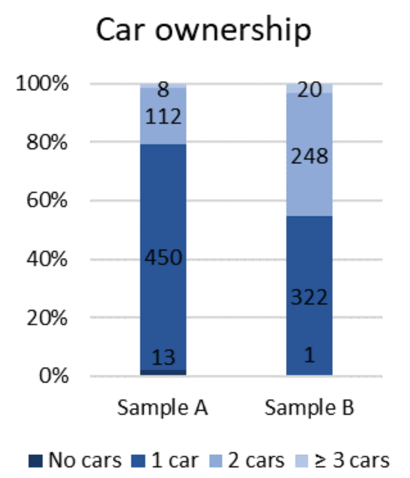

Figure 24: Household car ownership

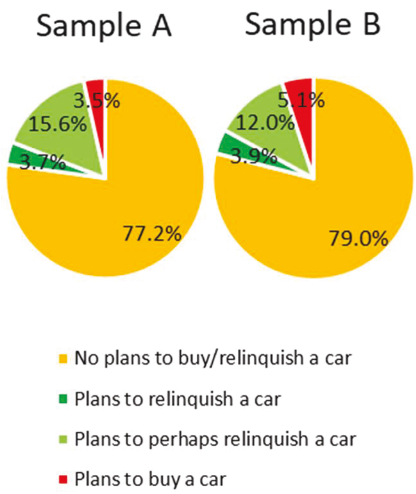

Figure 25: Planned car ownership (only households with ≥ 1 car)

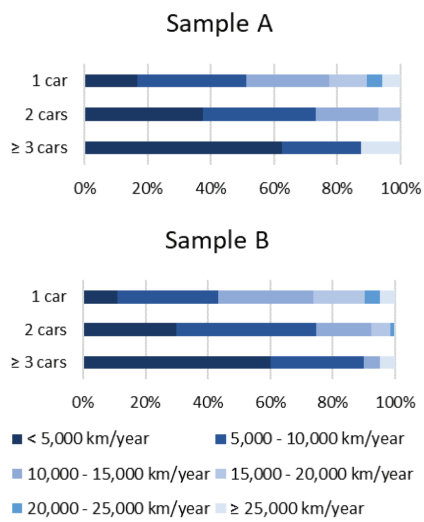

Figure 26: Distance of (least used) car

7.2.2 Use of shared modes

Residents of the inner-city neighbourhoods included in sample A use shared modes on a more regular basis than residents of the VINEX-neighbourhoods included in sample B (see Figure 27). The Chi-square test shows that the frequency of using shared modes significantly differs between both neighbourhoods (χ^2=53.114, p=0.000, df=6). This is probably strongly related to the higher densities of shared modes in the neighbourhoods included in sample A (see section 5.3). Concerning the association between household car ownership and frequency of use of shared modes, it is concluded that residents of sample A who possess more than one car in their household are more likely to use shared modes, compared to residents owning one car (χ^2=11.413, p=0.003, df=2; τ_b= -0.110, p=0.018). The same does not apply to residents of sample B (χ^2=2.843, p=0.241, df=2). It should be noted that the categories of household car ownership (1 car, >1 car) and frequency of shared mode use (≥1d/month, 1d/month-1d/year, never) were merged in order to meet the requirements of the Chi-square test. Shared cars, e-cargo bicycles and mopeds are more often chosen by residents of sample A, whereas the shared bicycle and e-bicycle are more often chosen by residents of sample

B (see Figure 28). The share of shared mode users is relatively high in sample A (18.4%) and sample B (8.1%). This is mainly explained by the relatively high share of shared moped users in sample A and the relatively high share of shared bicycle users in sample B. The relatively high shares of shared mode users may indicate that these users are overrepresented in the samples. This may be caused by the fact that these people are more interested in the topic of the survey, resulting in a higher response rate. Unfortunately, exact percentages of shared mode users among the population of The Hague and the Netherlands are unknown, so this overrepresentation cannot be confirmed. When considering carsharing users, the share of carsharing users of the samples (3.9% in sample A and 1.4% in sample B) is higher than the share of carsharing users in the Netherlands, which is approximately 1% when considering people above 18 years (KiM, 2015). However, several studies show that inhabitants of urban areas are more likely to participate in carsharing (KiM, 2015), which may explain the higher shares of carsharing users in the samples.

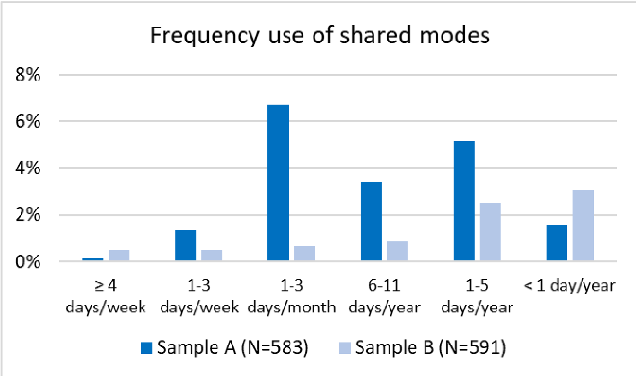

Figure 27: Frequency use of shared modes

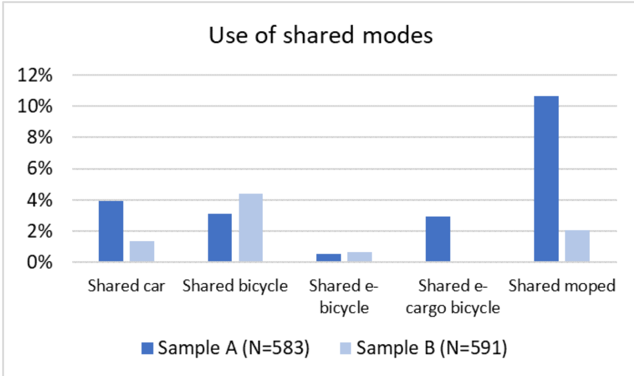

Figure 28: Use of shared modes

With regard to sample A, the shared moped is most often chosen in all categories of frequency of shared mode use, except among few residents who use shared modes ≥4 days/week or less than 1 day/year (see Figure 29). Subsequently, the shared car and e-cargo bicycle are most often chosen among residents of sample A who use shared modes 1-3 days/month, whereas the shared bicycle is most often chosen among residents who use shared modes 6-11 days/year. On the other hand, the shared moped is most often chosen in the categories 1-3 days/month and 6-11 days/year among residents of sample B, whereas the shared bicycle is most often chosen in the categories ≥4 days/week, 1-5 days/year and <1 day/year (Figure 30). Subsequently, the shared moped is most often chosen among residents who use shared modes 1-5 days/year and the shared car is most often chosen among residents who use shared modes less than 1 day/year.

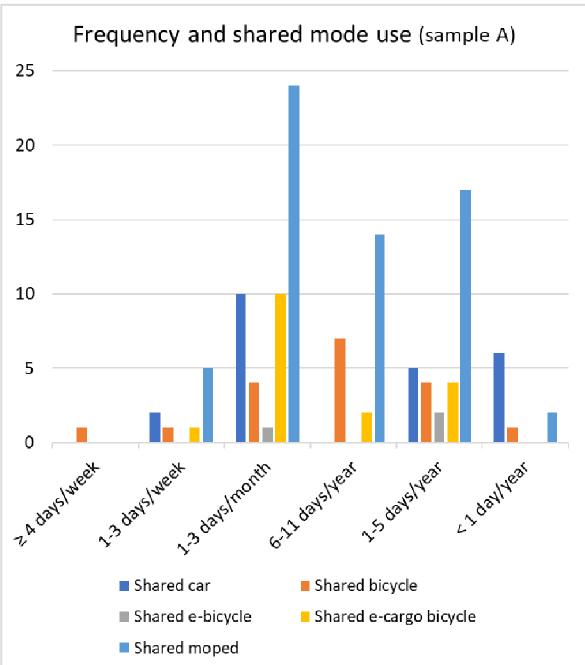

Figure 29: Frequency and shared mode use, sample A

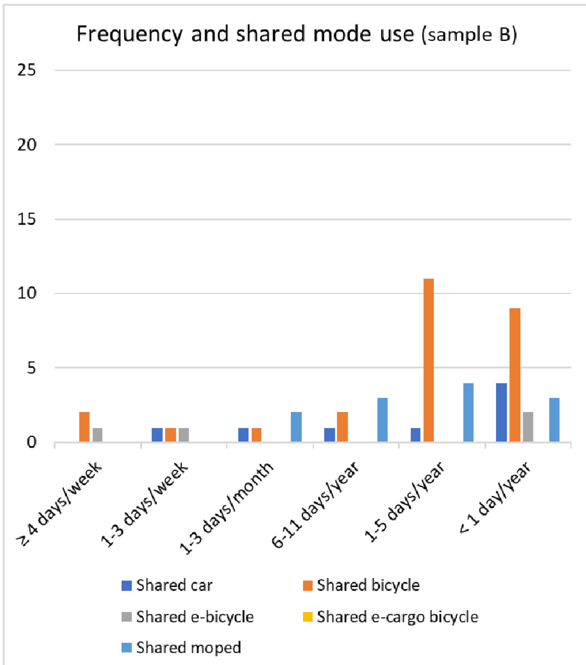

Figure 30: Frequency and shared mode use, sample B

The relation between socio-demographic characteristics, frequency of mode use and shared mode use
Older people are currently less likely to use shared modes in both samples (see Table 14). This corresponds to previous research that indicated that carsharing is less likely to be used among older people (section 2.3.1). Additionally, higher-income households and households with more cars are more likely to use shared modes in the inner-city neighbourhoods of sample A. Furthermore, frequent train users and frequent moped users are more likely to use shared modes in both samples. The correlation between frequent moped users and shared mode users is stronger in sample A than in sample B. This is probably inherent to the larger supply of shared mopeds in the inner-city neighbourhoods of sample A. Besides, frequent BTM users in sample A are more likely to use shared modes. There is no correlation between frequency of car use and frequency of shared mode use. This means that people who more often use the car do not necessarily use shared modes less often.

*Table 14: Kendall's tau-b correlation matrix of relation between socio-demographic characteristics/frequency of transport mode use and shared mode use for car owners in sample A and sample B, * p ≤ 0.05, ** p ≤ 0.01*

Socio-demographic characteristics	Sample A	Sample B	Frequency of transport mode use	Sample A	Sample B
Gender	-0.040	-0.060	Frequency of car use	-0.033	-0.042
Age	-.236**	-.115**	Frequency of train use	.180**	.183**
Education	.099*	0.067	Frequency of BTM use	.092*	0.058
Household income	.133**	0.031	Frequency of (e-)bike use	0.057	0.055
Number of cars	.106**	-0.034	Frequency of walking	-0.019	-0.013
Distance (least used) car	0.031	0.034	Frequency of moped use	.390**	.089*
Extensive correlation matrix including all p-values has been included in Appendix C1					

Shared modes within a 500-meter range
The use of shared modes is strongly related to the availability of these modes in the proximity of the dwellings. Figure 31 and Figure 32 show the availability of the shared modes within 500 meter of the respondents' dwelling according to the respondents themselves. Surprisingly, many respondents in both samples do not know whether a specific shared mode can be found within 500 meters distance of their dwelling. Moreover, there are differences among the residents of both samples. Most of the residents (50.1%) in sample A say that there is a shared car within 500-meter distance of their dwelling, whereas a small proportion (8.0%) of the residents in sample B says the same. Additionally, many residents of sample A (46.3%) know that there is a shared e-moped within 500 meters of their dwelling. Furthermore, many residents in sample B know that there is no shared mode in the proximity of their dwelling. This is strongly related to the actual supply of these shared cars (see section 5.3). The supply of shared modes is considerably smaller in neighbourhoods of sample B compared to the neighbourhoods of sample A.

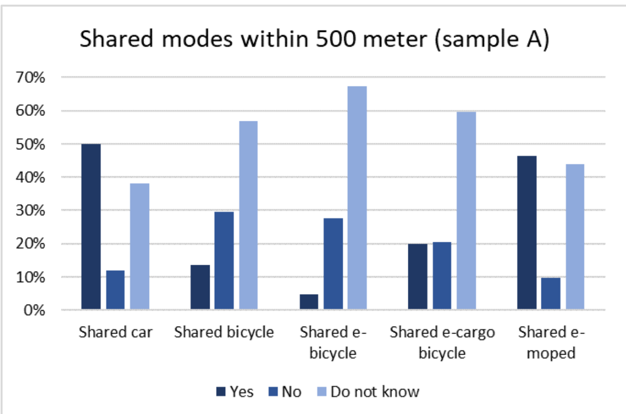

Figure 31: Shared modes within 500-meter range, sample A

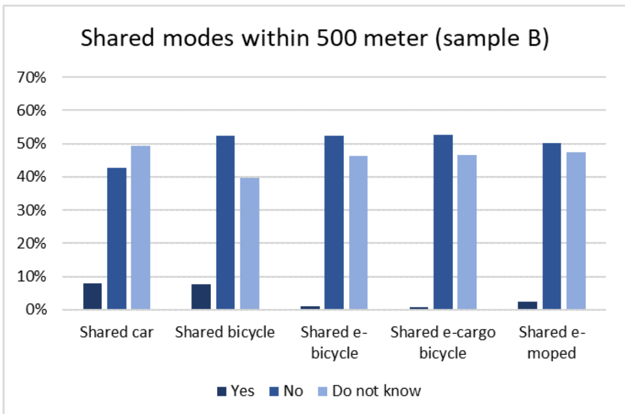

Figure 32: Shared modes within 500-meter range, sample B

It is concluded that there is no significant difference in familiarity with shared modes within 500-meter range among residents possessing one car and more than one car (see Appendix C2). When considering the frequency of shared mode use and the familiarity with shared modes, it is concluded that residents of both samples do more often know that there is a shared mode in the proximity of their dwelling if they use one of the shared modes (see Appendix C3). However, it cannot be concluded that residents who use shared modes more frequently, are more likely to know that there are shared modes in the proximity of their dwelling. The familiarity with shared modes in the proximity of the resident's dwelling in relation to the use of these shared modes has also been investigated (see Appendix C4). It is concluded that residents of sample A who use e-cargo bicycle, always know that there is a shared e-cargo bicycle in the proximity of their dwelling (N=17). Additionally, residents who use the shared moped and shared car are also familiar with these modes in the proximity of their dwelling (93.5% and 87.0%). Furthermore, 27.8% of the residents who use the shared bicycle do know that there is a shared bicycle in the proximity of their dwelling. This is probably inherent to the added value of the shared bicycle on the egress side of the trip (section 2.3.2). Residents of sample B are less familiar with shared modes in the proximity of their dwelling if they use these shared modes. For instance, 37.5% of the residents who use shared cars knows that shared cars are in the proximity of their dwelling. Again, the familiarity with the shared bicycle is relatively low among residents who use this shared mode (19.2%).

Familiarity with the mobility hub

The familiarity with the concept of a mobility hub is depicted in Figure 33. More residents in sample B (26%) are familiar with the concept of a mobility hub compared to the residents of sample A (22%). However, the Chi-square test shows that the difference between sample A and sample B is not significant (χ^2=2.261, p=0.133, df=1).

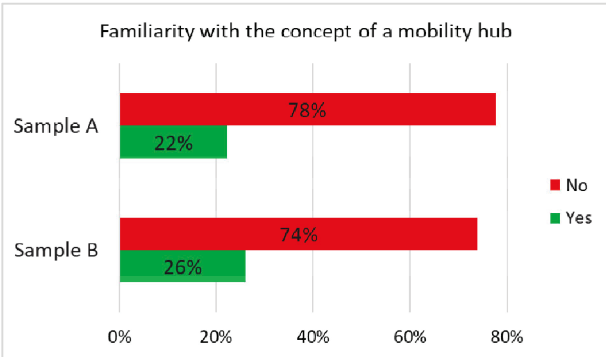

Figure 33: Familiarity with the concept of a mobility hub

7.2.3 Attitudes & social norm

Figure 34 shows the opinions of the residents in sample A and B on a Likert scale regarding the statements about attitudes and social norm. Most residents agree that the car gives them freedom. In turn, most residents disagree that the car says a lot about someone's social status. The answers of residents of sample A and B are approximately the same, although there are some small deviations between both samples. For instance, residents of sample B are less likely to (completely) agree that they would not need their car anymore if shared cars become available anywhere at any time. Thus, residents of the VINEX-neighbourhoods are more likely to rely on their car. KiM (2016b) concluded that this can be explained by the socio-demographic characteristics of residents of VINEX-neighbourhoods. The location close to the highway and the less extensive public transport network may also contribute to that.

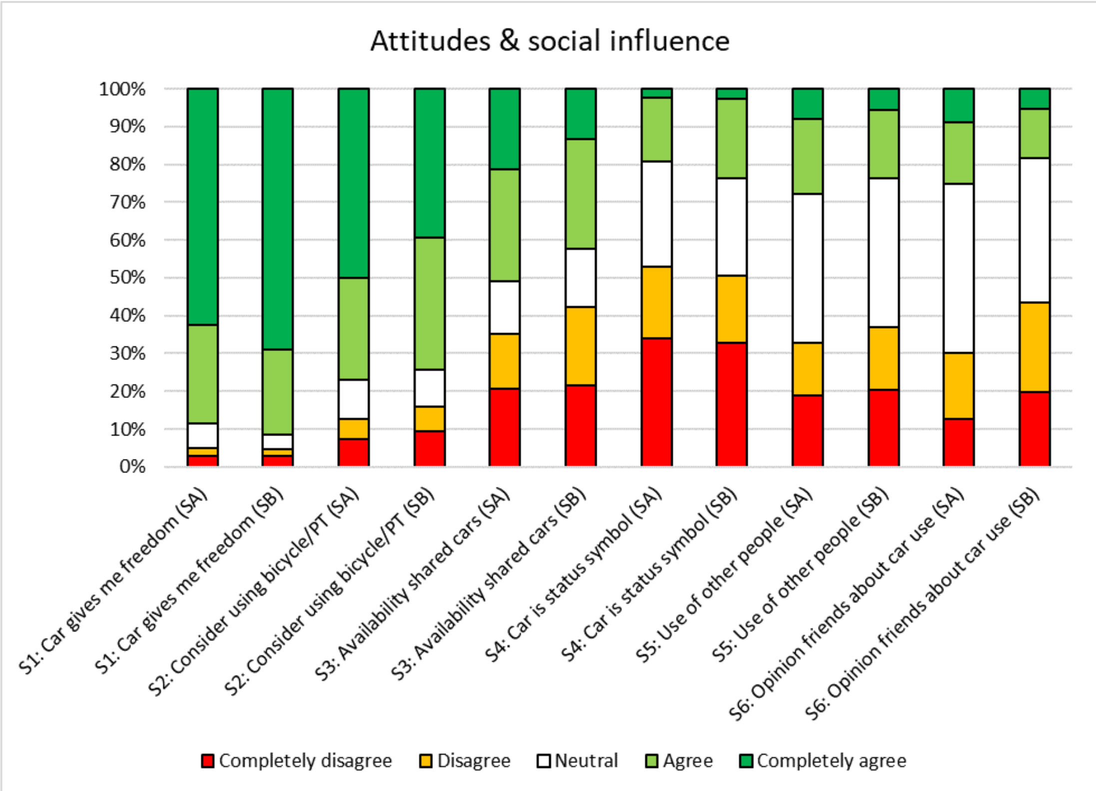

Figure 34: Statements about attitudes and social norm among car owners in sample A (N=570) and sample B (N=590)

Relation between statements

The statements of a respondent are correlated between themselves (see Appendix C5). For instance, respondents who agree that the car gives them freedom are less likely to consider using a bicycle and/or PT. Besides, these residents less often agree with the statement that they do not need a car if shared cars become available anywhere at any time. Additionally, people who sometimes consider using the bicycle and/or PT are more likely to agree that they do not need a car if shared cars become available anywhere at any time. This indicates that people who already (sometimes) consider bicycle and/or PT are more likely to get rid of their cars when shared modes become available. Concerning the statements about social norm, people who more often choose for sustainable modes if other people would do the same, have more often friends who think that you should only use the car if needed.

Furthermore, statements related to attitudes (statements 1-3) are associated with statements about social norm (statements 4-6). For instance, residents who agree that their friends think that you should only use the car if needed are more likely to consider using a bicycle and/or PT at least sometimes. Besides, these people more often agree that they do not need a car if shared cars would be available anywhere at any time. Also, residents who agree that they would choose more often for sustainable modes if other people would do the same, are more likely to sometimes consider using the bicycle and/or PT. Moreover, these people more often indicate that they would not need a car anymore if shared cars would be available anywhere at any time.

The relation between statements, gender, and age

The statements about attitudes and social norm are also correlated with gender and age (Table 15). Women more often agree that the car gives them freedom. In contrary, men more often agree that the car says a lot about someone's social status. Women in sample B are more likely to choose more often for sustainable transport modes, if other people do that as well. Previous research showed that women are found to be more concerned with environmental issues in their transport mode choices (Bouscasse, Joly, & Bonnel, 2018). Furthermore, older people in sample A more often agree that their friends think that you should only use the car if needed in comparison with younger people. Besides, older people in sample B are less likely to be affected by the decisions of other people regarding sustainable transport mode choice. This can be explained by the stronger attachment to their car among older people (Prieto et al., 2017).

The relation between statements & frequency of mode use

The degree of agreement with the statements is also correlated with the frequency of transport mode use (see Table 15). Residents who agree that they sometimes consider using the bicycle and/or PT are less likely to use the car, and more likely to use the train, BTM and bicycle. Additionally, residents who agree that they do not need their car if shared cars would be available anywhere at any time are also less likely to use the car and more likely to use the train, BTM and the bicycle. Furthermore, residents who agree that the car gives them freedom are more likely to use the car, whereas they use the train and bicycle less often. Besides, residents of sample A who agree with this statement are also less likely to use the BTM, while residents of sample B are less likely to walk to their destination. Residents who agree that they would choose more often for sustainable modes if other people would do the same are more likely to use the train, BTM, and the bicycle. Residents who agree that their friends think that you should only use the car if needed are less likely to use the car and more likely to use the train and the bicycle.

The relation between statements and frequency of shared mode use

Residents who agree that the car gives them freedom are currently less likely to use shared modes (see Table 15). Besides, residents who agree that they do not need their car if the shared cars are available anywhere at any time are more likely to use shared modes. Furthermore, residents in sample A are more likely to use shared modes if they agree that they sometimes consider using the bicycle and/or PT. These residents are less likely to use shared modes if they agree that the car says a lot about someone's social status.

*Table 15: Kendall's tau-b correlation matrix for car owners in sample A (N=570) and sample B (N=590), * p ≤ 0.05, ** p ≤ 0.01*

Statement	Sample	Gender[a]	Age[b]	Car[c]	Train[c]	BTM[c]	Bicycle[c]	Walking[c]	Shared modes[c]
S1: The car gives me freedom	Sample A	.104**	-0.026	.224**	-.178**	-.078*	-.139**	-0.041	-.125**
	Sample B	.095*	0.005	.119**	-.113**	-0.063	-.098**	-.085*	-.082*
S2: I sometimes consider using the bicycle and/or public transport instead of the car	Sample A	0.015	0.035	-.260**	.182**	.127**	.281**	0.057	.087*
	Sample B	0.013	-0.025	-.212**	.213**	.242**	.263**	.122**	0.040
S3: If shared cars would be available anywhere at any time, I do not need my car	Sample A	0.036	-0.034	-.221**	.179**	.113**	.139**	0.035	.108**
	Sample B	0.055	-0.055	-.197**	.126**	.099**	.110**	0.003	.091*
S4: A car says a lot about someone's social status	Sample A	-.144**	0.056	.108**	-0.036	-0.001	-.079*	-.093*	-.084*
	Sample B	-.136**	0.043	0.048	-0.041	-0.051	-0.032	0.00	0.048
S5: If other people would choose more often for sustainable modes, I would do that as well.	Sample A	0.006	-0.059	-0.047	.138**	.076*	.107**	-0.053	0.069
	Sample B	.099**	-.079*	-0.066	.127**	.091**	.082*	0.024	0.064
S6: My friends think you should only use the car if needed	Sample A	0.052	.095**	-.156**	.074*	0.002	.157**	0.014	-0.010
	Sample B	0.055	0.012	-.099**	.067*	0.064	.081*	0.025	0.005

[a] 1= men, 2= women
[b] 1= <20years, 2= 20-45 years, 3= 45-65 years, 4= 65-80 years, 5= ≥80 years
[c] 1= never, 2= <1day/year, 3= 1-5 days/year, 4= 6-11 days/year, 5= 1-3 days/month, 6= 1-3 days/week, 7= ≥4 days/week
Extensive correlation matrix including all p-values has been included in Appendix C6

7.3 Preferred systems and the intention to use shared modes

Preferred carsharing systems and mobility hubs and the intention to use shared modes provided by these systems and mobility hubs have been investigated by two stated choice experiments. The results presented in this section answer the following research question:

RQ2: What characteristics influence the intention to use shared modes provided by mobility hubs and to what extent do these characteristics differ between mobility hubs and carsharing systems among residents of the investigated neighbourhoods in The Hague?

The first two sections are aimed at investigating preferred carsharing systems and mobility hubs and the intention to use shared modes provided by these systems. The subsequent section focuses on the calculation of the system and mode probabilities for specific defined scenarios.

7.3.1 Preferred systems

Table 16 shows the results of the stated choice experiments aimed at investigating the characteristics that influence the choice of preferred carsharing systems and mobility hubs. The system, trip, socio-demographic characteristics and statements about attitudes and social norm have been included in the final ML models. The adjusted rho squared of the best estimated ML models are 0.308 (sample A) and 0.297 (sample B) in the model of preferred carsharing systems and 0.290 (sample A) and 0.291 (sample B) in the model of the preferred mobility hubs. Compared to the MNL models (Appendix D1 & D3), the ML models show large improvements in adjusted rho squares since the panel effects are incorporated. Hensher et al. (2005) argued that models with a rho-square between 0.2 and 0.4 are considered as good fits. Therefore, these ML models are considered as good fits and are discussed below.

Table 16: Estimation results preferred systems

	Preferred carsharing systems				**Preferred mobility hubs**			
	Sample A		**Sample B**		**Sample A**		**Sample B**	
Model (draws)	ML (1000 draws)		ML (1000 draws)		ML (1000 draws)		ML (1000 draws)	
# est. parameters	12		12		12		14	
# observations	2200		2240		2280		2360	
# individuals	550		560		570		590	
Final log LL	-1660.846		-1717.006		-1767.053		-1824.139	
Rho square	0.313		0.302		0.295		0.296	
Adj. rho square	0.308		0.297		0.290		0.291	
Parameter	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
ASC_{system}	2.35	0.00	1.07	0.14				
ASC_{hub}					0.521	0.35	-1.77	0.01
$\beta_{shared\ car}$					1.23	0.00	1.05	0.00
$\beta_{travel\ costs}$	-0.620	0.00	-0.508	0.00				
$\beta_{travel\ costs\ OM}$					0.510	0.00	0.451	0.00
$\beta_{walking\ time}$	-0.602	0.00	-0.604	0.00	-0.828	0.00	-0.790	0.00
$\beta_{reservation}$	-0.799	0.00	-0.436	0.00	-0.568	0.00	-0.534	0.00
$\beta_{known\ users}$	0.244	0.00	0.357	0.00	0.322	0.00	0.264	0.00
$\beta_{no\ return\ needed}$			-0.254	0.00				
$\beta_{work/business}$							1.81	0.00
$\beta_{45-65\ years}$	-1.93	0.01	-1.51	0.02	-2.13	0.00	-1.77	0.00
$\beta_{\geq 65\ years}$	-3.89	0.00	-3.92	0.00	-3.43	0.00	-3.73	0.00
$\beta_{high\ income}$	1.17	0.03						
$\beta_{t\ without\ children}$					-1.61	0.00		
$\beta_{one-parent}$	3.18	0.02						
$\beta_{statement2}$			2.13	0.00			1.13	0.04
$\beta_{statement3}$	4.32	0.00	3.22	0.00	2.56	0.00	2.48	0.00
$\beta_{statement4}$	1.48	0.04					1.31	0.02
$\beta_{statement5}$			1.68	0.01	1.78	0.00	1.85	0.00
ζ_{system}	-5.04	0.00	-5.29	0.00	-4.20	0.00	4.67	0.00

System characteristics

The alternative specific constant of the preferred car sharing systems is positive in both samples, which means that choosing one of the carsharing systems is preferred over the option “None”. This also applies to the preferred mobility hubs in sample A. However, the option “None” is preferred over the mobility hubs in sample B, when keeping all other parameters zero. All ASC’s are larger in the case of sample A, compared to sample B. This indicates that residents of the inner-city neighbourhoods of sample A are more likely to choose carsharing systems and mobility hubs than residents of the VINEX-neighbourhoods of sample B. This is also found by Prieto et al. (2017), who concluded that respondents living in city centres are positively associated with carsharing adoption intention.

Almost all attributes of the system characteristics have expected (positive/negative) signs. The availability of a shared car has a positive effect on the utility of mobility hubs. Increasing travel costs for the carsharing system has a negative effect, while decreasing travel costs for the shared moped and e-(cargo)bicycle have a positive effect on the choice for mobility hubs. Furthermore, increasing walking times and a reservation obligation have negative effects, whereas sharing with known users has a positive effect for both the carsharing system and the mobility hub. The only surprising result is the negative value for the attribute “no return needed” in the preferred carsharing systems in sample B. No return needed is more negatively assessed than return to the pick-up point. It could be “return to pick-up point” is assessed to be safer, so that the shared car is available again the next time. Besides, it could be that respondents did not read the explanation of return location well and assess return to a location of your choice more difficult due to searching time for a parking place.

Walking time and travel costs were found to have linear effects on the utility. Therefore, these attributes have been added to the models as linear parameters, similar to e.g. Winter, Cats, Martens, and van Arem (2017). This means that the effect on the utilities is two times as large for a system at 9 minutes walking distance, compared to a system at 6 minutes walking distance. Similarly, increasing the costs of the carsharing system from €0.20/km to €0.30/km has the same effect on the utility as increasing the costs from €0.30/km to €0.40/km. This also applies to the travel costs of the moped and e-(cargo)bicycle provided by the mobility hubs. Reducing the costs of these modes from €0.40/km to €0.30/km has the same effect as reducing the costs from €0.30/km to €0.20/km.

The travel costs have a larger effect on the utility in sample A, compared to sample B. This indicates that residents of investigated inner-city neighbourhoods are more cost-sensitive than residents of investigated VINEX-neighbourhoods. In addition, the values of walking time show similar magnitudes among both samples, which means that walking time is assessed to be equally negative in both neighbourhoods. However, the effect of increasing walking times for mobility hubs is larger compared to the effect of increasing walking times in the case of carsharing systems. This is probably related to the smaller average trip distance of the last car trip to a destination in The Hague in comparison with the last car trip. The average distance of the last car trip to a destination in The Hague is respectively 7.0 km (sample A) and 8.3 km (sample B), compared to 43.1 km (sample A) and 25.5 km (sample B) for the last car trip. Furthermore, a reservation obligation is considerably more negatively assessed in sample A, concerning the carsharing systems. Residents of VINEX-neighbourhoods may have a more planned life with more constant travel patterns, whereas residents of inner-city neighbourhoods may have more spontaneous travel patterns. However, the reservation obligation is found to be as negative in both samples regarding the mobility hubs.

Based on the estimated parameters in the ML models, trade-offs between system characteristics can be calculated. For instance, the absence of a shared car in a mobility hub can be compensated by reducing the travel costs of the other shared modes from €0.40/km to €0.10/km. An increase in walking time of 3 minutes can be compensated by reducing the travel costs by €0.20/km. Introducing a reservation obligation has approximately the same as effect as increasing travel costs by €0.10/km.

Trip characteristics
None of the trip characteristics has been included in the final ML models of preferred carsharing systems, whereas the trip purpose “work/business” is the only trip characteristic included in the ML model of preferred mobility hubs. The mobility hub is preferred for work/business trips among residents of sample B. This is not supported by previous research regarding carsharing systems. Previous literature studies found trip purposes related to visiting family and friends to be a determinant for the (intention to) use shared cars (Dieten, 2015; KiM, 2015). However, people may consider using the shared moped, e-bicycle and/or e-cargo bicycle as an interesting alternative to the conventional car for work/business trips to avoid e.g. traffic jams.

Socio-demographic characteristics
Older people are significantly less likely to choose a preferred carsharing system or mobility hub. This effect is larger for people of 65 years and older compared to people between 45 and 65 years. That is consistent with current users of carsharing systems. For instance, TNS NIPO showed that around 75% of carsharing users in the Netherlands is between 30 and 60 years old (KiM, 2015). Additionally, people between 45 and 65 years in sample A are less likely to choose preferred carsharing systems and mobility hubs than equally old people in sample B. Moreover, higher income households (≥€41,600/year) in the inner-city neighbourhoods are more likely to choose a preferred carsharing system. The costs of the carsharing systems may form an obstacle for the households with a lower yearly income. Additionally, one-parent households are more likely to choose a preferred carsharing system in sample A. In contrary, Kopp et al. (2013) found that households without children are more likely to choose for a preferred carsharing system. Furthermore, people living together without children ($\beta_{t\ without\ children}$) in neighbourhoods of sample A are less likely to choose a preferred mobility hub.

Attitudes & social norm
The contribution of attitudes and social norm has a larger effect on the utility among residents of sample B compared to sample A. This indicates that attitudes and social norm are more important in VINEX-neighbourhoods rather than inner-city neighbourhoods of The Hague. This is probably related to the characteristics of the inhabitants of these neighbourhoods, also accounting for relatively high car use (KiM, 2016b). Statement 3 (If shared cars would be available anywhere at any time, I do not need my car) is most important in both models and samples. This indicates that the attachment to their car is a strong determinant in the choice for a carsharing system or a mobility hub instead of none of the systems. Additionally, statement 2 (I sometimes consider using the bicycle and/or PT instead of the car) and statement 5 (If other people would choose more often for sustainable modes, I would do that as well) are strong determinants in sample B. The latter statement is also important among residents of sample A in the case of mobility hubs. Furthermore, statement 4 (A car says a lot about someone’s social status) is an important factor in the preferred carsharing systems among residents of sample A and mobility hubs among residents of sample B.

Panel effects
The ML model incorporates the panel effects by an additional error term, which is normally distributed with a standard deviation. This means that the different respondents experience a different utility, keeping all other parameters equal. Thus, some residents experience the carsharing systems and mobility hubs more positively (positive drawn number) than the “None”-alternative, whereas other residents experience these systems more negatively (negative drawn number). To determine the exact utility for all alternatives for some residents as much draws as residents should be drawn from this normal distribution. Some parameters included in the MNL models (see Appendix D1 & D3) became insignificant in the ML models, such as some trip and socio-demographic characteristics. Hensher et al. (2005) concluded that the correlation among choices of the same respondent can be “the product of many sources including the commonality of socio-economic descriptors that do not vary across the choice situations for a given sampled individual”. So, these factors may be incorporated in the error term for panel effects.

The standard deviation differs among both samples and systems. The absolute values of these standard deviations are smaller in sample A compared to sample B. Similarly, the absolute value of the standard deviation is smaller in the case of mobility hubs compared to car sharing systems. Accordingly, this means that the spread in experienced utilities is also smaller among sample A than sample B. The same applies for mobility hubs compared to carsharing systems. Residents of both samples experience less often very different utilities with the mobility hub.

Robustness of the model

As discussed, the adjusted rho squares of the ML models are considerably larger than the adjusted rho squares of the MNL models, which shows that the ML models better fit the choices of the residents. It should be noted that some parameters became insignificant in the ML models and were therefore removed from the model. As discussed in the section about the panel effects, these characteristics may be included in the error terms of the ML models. The final MNL models have also shortly been compared with the MNL models without the alternative “None” (Appendix D2 & D4). It is concluded that the insignificant hub characteristics (users and return location) have also not been included in the final MNL models. Furthermore, the magnitudes of the other system parameters have approximately the same value in the models of preferred carsharing systems and mobility hubs. This indicates that the final MNL models are robust.

Compared to the ML models without statements about attitudes and social norm (Appendix D2 & D4), the ASC’s of the final ML models have considerably decreased. The utility is largely moved to the statements about attitudes and social norm, indicating that the attitudes and social norm are important determinants of preferred carsharing systems and mobility hubs. The values of the other parameters did not significantly change, which implies that the final ML models are robust. The only parameter that became insignificant was income in the model of the preferred mobility hubs in sample A. Accordingly, this parameter was removed in the final ML model.

According to the theoretical framework, system, trip, socio-demographic characteristics and statements regarding attitudes and social norm are considered in the models of preferred carsharing systems and mobility hubs. Nevertheless, the alternative specific constants of sample A are not equal to the alternative specific constants of sample B. This implies that other characteristics affect the decision between preferred systems and determine the differences between both samples. This may be explained by different characteristics of the neighbourhoods included in sample A and sample B, such as the familiarity with the current supply of shared modes, not investigated attitudes or built environment characteristics.

Outside the scope of this research, it has been shortly analysed whether the familiarity with the current supply of shared modes within 500 meters of the respondent’s dwelling does influence the choice of preferred systems. However, it is concluded that the explanatory power of the models does not improve. Accordingly, these parameters have not been added to the final models.

7.3.2 Intention to use shared modes

Table 17 shows the results of the stated choice experiments aimed at investigating the intention to use shared modes of the preferred carsharing systems and mobility hubs. The system, trip, socio-demographic characteristics and statements about attitudes and social norm have been included in the final ML models. The ML models show again the best results in comparison with the MNL models (Appendix D5 & D7). The adjusted rho squares in the models about the intention to use the shared car of the preferred carsharing system are respectively 0.468 (sample A) and 0.444 (sample B). The adjusted rho squares in the models about the intention to use shared modes of the preferred mobility hub are 0.466 (sample A) and 0.506 (sample B). All ML models are considered as good fits (Hensher et al., 2005).

Table 17: Estimation results intention to use shared modes from preferred systems

	Model	**Intention to use the shared car of the preferred carsharing system**				**Intention to use the shared modes of the preferred mobility hub**			
		Sample A		**Sample B**		**Sample A**		**Sample B**	
	Model (draws)	ML (1000 draws)		ML (1000 draws)		ML (1000 draws)		ML (1000 draws)	
	# est. parameters	8		7		16		15	
	# observations	1485		1474		1354		1362	
	# individuals	426		423		412		415	
	Final log LL	-539.825		-560.913		-1147.362		-1066.856	
	Rho square	0.476		0.451		0.473		0.513	
	Adj. rho square	0.468		0.444		0.466		0.506	
Mode	**Parameter**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
All modes[a] *(generic)*	$\beta_{walking\ time}$					-0.701	0.00	-0.582	0.01
	$\beta_{<1day/week}$							1.77	0.01
	$\beta_{statement1}$					-2.40	0.02		
	$\beta_{statement3}$					3.22	0.00	3.24	0.00
	$\beta_{statement5}$							1.72	0.05
	ζ_{hub}					4.34	0.00	-5.64	0.00
Shared car	$ASC_{shared\ car}$	-1.52	0.21	-5.59	0.00	-1.06	0.31	-5.40	0.00
	$\beta_{travel\ costs}$	-0.800	0.00	-0.821	0.00				
	$\beta_{walking\ time}$	-0.500	0.00	-0.724	0.00				
	$\beta_{known\ users}$					-0.709	0.00		
	$\beta_{shopping}$	-2.50	0.02						
	$\beta_{visiting}$			1.98	0.03				
	$\beta_{statement1}$	-4.45	0.00						
	$\beta_{statement2}$			1.99	0.04				
	$\beta_{statement3}$	5.74	0.00	4.09	0.00				
	$\beta_{statement5}$	1.75	0.02						
	$\zeta_{shared\ car}$	-5.68	0.00	5.77	0.00				
Shared moped[a]	ASC_3					-8.50	0.00	-9.58	0.00
	$\beta_{travel\ costs\ OM}$					0.555[b]	0.00	0.671[b]	0.00
	$\beta_{>15km}$					-4.65[c]	0.00		
	$\beta_{work/business}$							1.81	0.05
	$\beta_{visiting}$							2.65	0.02
	$\beta_{high\ income}$					2.55	0.02		
	ζ_3					-6.15	0.00	3.56	0.00
Shared e-bicycle[a]	ASC_4					-5.43	0.00	-9.45	0.00
	$\beta_{travel\ costs\ OM}$					0.555[b]	0.00	0.671[b]	0.00
	$\beta_{>15km}$					-4.65[c]	0.00		
	ζ_4					-6.11	0.00	-8.70	0.00
Shared e-cargo bicycle[a]	ASC_5					-13.9	0.00	-15.5	0.00
	$\beta_{travel\ costs\ OM}$					0.555[b]	0.00	0.671[b]	0.00
	$\beta_{t\ with\ children}$					6.78	0.00		
	ζ_5					-9.74	0.00	-9.20	0.00

[a] Alternatives are only included in the models about the intention to use shared modes of the preferred mobility hub

[b] same variable is included in shared moped/e-(cargo)bicycle *[c] same variable is included in shared moped/e-bicycle*

It should be noted that the presented results should be consulted together with the models of the preferred systems (see section 7.3.1) to calculate the probabilities of choosing a shared mode (see section 7.3.3).

System characteristics

The ASC's of the shared car and the other shared modes (in the model about the mobility hubs) are negative in both samples. This means that the own car is preferred over the shared modes, keeping all other parameters equal to zero. This is a logical decision since the own car is already largely being paid and the variable costs are relatively low. Furthermore, the shared car has the largest ASC in the models about the intention to use the mobility hubs. Thus, residents are most likely to choose the shared car among the shared modes, which is a logical decision as the shared car has most similar characteristics to the conventional car. Residents of sample A are more likely to choose the shared car compared to residents of sample B. The neighbourhoods of sample A are more densely populated with a smaller average distance to public transport stops than neighbourhoods of sample B. Previous research confirmed that residents of densely populated areas with a close distance to public transport stops are most likely to adopt for shared cars (KiM, 2015; Kopp et al., 2013, 2015). The same applies also to the other shared modes provided by the mobility hub, since the ASC's of sample A are larger than the ASC's of sample B.

Compared to the ML models about preferred carsharing systems and mobility hubs, there is a relatively small number of system parameters included in the estimated models. The reason for this is that only preferred systems are considered here. The other system characteristics have already been considered in the choice of preferred carsharing systems and mobility hubs (see section 7.3.1). Travel costs and walking time are the only two system characteristics that affect the choice between the own car and the shared car. The importance of travel costs in the choice between the own car and shared car is also found in previous research. For instance, Duncan (2011) concluded that a key element for the potential growth of sharing is the ability to provide cost savings. Walking time is the only generic parameter included in the final ML model of the intention to use shared modes offered by the mobility hub. Here, the travel costs are included in the shared moped and e-(cargo)bicycle, as reducing the travel costs of these modes leads to a higher utility of these modes. Furthermore, sharing with known people leads to a lower utility of shared cars among residents of sample A in the model about the intention to use shared modes of the preferred mobility hub. Thus, residents of sample A prefer sharing with known and unknown people. This may be related to the availability and reliability of the modes. Sharing with only known people may lead to unavailability of the specific shared mode for a certain period. In contrary, shared modes which are used by known and unknown people, generally have a larger supply, which makes these modes more reliable.

Travel costs are equally negative assessed among residents of both samples in the model about the intention to use the preferred carsharing system. However, reducing the travel costs of the shared moped and e-(cargo)bicycle in the model about the intention to use the preferred mobility hub has a higher positive effect among residents of sample B compared to sample A. Thus, residents of sample B are more cost-sensitive when considering the choice between the car/shared car and the other shared modes. Residents of inner-city neighbourhoods may more often consider other modes than the conventional car in their transport mode decision. As a result, they currently choose more often for the bicycle and public transport (see section 7.1) and use the conventional car only if necessary. As a result, they might be less cost-sensitive concerning the costs of the shared moped and e-(cargo)bicycle. The walking time to the carsharing system is more negatively assessed in sample B compared to sample A, whereas the walking time to the mobility hub has larger negative effects in sample A. So, residents of sample A are more likely to walk a longer distance to a carsharing system while they are less likely to walk a longer distance to a mobility hub, in comparison with residents of sample B. It should be noted that the intention to use a carsharing system has been investigated in the context of the last car trip from home, whereas the intention to use a mobility hub has been investigated in the context of the last car trip from home to a destination in The Hague. An explanation for the different results may be the lower average trip distance of the last car trip to a destination in The Hague in sample A (7.0 km) compared to sample B (8.3 km), resulting in a larger share of walking distance in the total distance of shorter trips. The longer average distance in sample B might be explained by the location of the VINEX-neighbourhoods, further away from the other neighbourhoods.

Trip characteristics

The shared car of the preferred carsharing system is less likely to be used for shopping/groceries trips among residents of sample A. An explanation might be that residents dislike walking with their groceries from the carsharing system to their home. Additionally, the shared car offered by preferred carsharing systems is more often preferred for visits in sample B. This is also found by Dieten (2015), who investigated the willingness to choose a carsharing system among different trip purposes. People were significantly more likely to choose a preferred carsharing system for the purpose visits, whereas other trip purposes did not show significant results. Additionally, KiM (2015) concluded that Dutch carsharing users more often use the shared car for visiting trip purposes. The same does not apply for shared cars offered by a mobility hub, although the trip purpose may be incorporated by the individual or generic panel effects as the purpose visits was significant in the MNL models (Appendix D7). The shared moped offered by the mobility hub is more likely to be used for work/business-related trips and visits.

Residents of sample B are more likely to choose shared modes offered by the mobility hubs for infrequent trips (< 1 day/week). This is also supported by several literature studies. For instance, KiM (2015) found that the majority of carsharing users do infrequently use the shared car. Almost two-thirds of the Dutch users use the shared car for less than three times per year. Furthermore, the shared moped and e-bicycle are less likely to be used for longer trips (>15 km) in sample A, inherent to the characteristics of these modes. Surprisingly, the shared e-cargo bicycle is not less likely to be used for longer trips to a destination in The Hague. However, when comparing the final ML models with the MNL models (Appendix D7), it appeared that the e-cargo bicycle is less likely to be used for trips over 5 km in the MNL models. These characteristics may be included in the error term for the panel effects in the ML model since there is a correlation among the choices for one specific trip. In contrary to the models about the intention to use shared modes offered by the preferred mobility hubs, no other trip characteristics are found to be significant in the final ML models about the intention to use the shared car of the preferred carsharing systems.

Socio-demographic characteristics

High-income households (≥€41,600/year) in sample A are more likely to use the shared moped, whereas people living together with children ($\beta_{t\ with\ children}$) in sample A more often prefer the e-cargo bicycle. This is probably related to the characteristics of the e-cargo bicycle: the ability to transport children. No other socio-demographic characteristics influence the choice between the own car and the shared car/modes. However, it should be noted that e.g. younger people (<45 years) have more often preferred carsharing systems and mobility hubs over the alternative “None” and have successively filled in more often the question about the intention to use the shared car/modes. Therefore, this model is no stand-alone model but must be consulted together with the former models about the preferred systems. Furthermore, these factors may be incorporated by the error term for panel effects, as some excluded socio-characteristics in the ML model are significant in the final MNL models (Appendix D5 & D7). This might be caused by the correlation of the respondent’s choices.

Attitudes & social norm

The statements about attitudes and social norm have a relatively large effect on the utility of the shared car/modes. This implies that the choice between the own car and the shared car/modes is strongly affected by attitudes and social norm. Many literature studies have confirmed that attitudes and social norm are an important determinant for the intention to use (Ajzen, 1991; Dwivedi et al., 2019). Agree with statement 3 (If shared cars would be available anywhere at any time, I do not need my car) is the most important statement among residents of both samples. This applies to the models about the intention to use the shared car offered by the preferred carsharing systems, as well as to models about the intention to use the shared modes offered by the preferred mobility hubs. If residents of sample A agree with statement 1 (The car gives me freedom), they are less likely to use the shared car/modes. If residents of sample A agree with statement 5 (If other people would choose more often for sustainable modes, I would do that as well), they are more likely to use a shared car offered by the preferred carsharing systems. In contrary, residents of sample B are more likely to use the shared modes offered by the preferred mobility hubs, if they agree with this statement.

Additionally, residents of sample B who agree with statement 2 (I sometimes consider using the bicycle and/or PT instead of the car) are more likely to use the shared car offered by the preferred carsharing system.

Panel effects

The model about the intention to use the shared car offered by the carsharing system includes an error term with standard deviation $\zeta_{shared\ car}$. Whereas some people experience a relatively high utility of the shared car, other people experience a relatively low utility of the shared car. Accordingly, the adoption of shared modes is very different among the residents within both samples. Regarding the models about the intention to use preferred mobility hubs, the utility specifications of the shared modes include a generic error term for the panel effects with a standard deviation ζ_{hub}. This means that choices for shared modes are correlated, i.e. some respondents experience a high utility with all shared modes, whereas other residents experience a low utility with all shared modes. The standard deviation is larger among residents of sample B compared to sample A, which indicates that the choices of residents of sample B are more often different. Additionally, individual normally distributed error terms with standard deviations are included in the utility specifications of the shared moped (ζ_3), e-bicycle (ζ_4) and e-cargo bicycle (ζ_5). This means that choices for specific shared modes are correlated as well, i.e. some residents experience more utility with one of these modes, while other residents experience less utility with this shared mode. The standard deviation of the error term of the shared moped is considerably smaller among residents of sample B. This indicates that the experienced utilities with the shared moped are more similar among residents of sample B compared to residents of sample A. In contrary, the standard deviation of the error term of the shared e-bicycle is smaller in sample A than in sample B, although both standard deviations are still relatively high. Thus, the experienced utilities of the shared e-bicycle are more similar among residents of sample A compared to sample B.

Robustness of the model

Compared to the final MNL models (Appendix D5 & D7), the ML models show considerable improvements regarding the model fit (adjusted rho square). Some significant parameters in the MNL model became insignificant and have been removed in the final ML models, similar to the models of the preferred systems. Hensher et al. (2005) concluded that these parameters can be included in the error terms for panel effects, as these parameters do not vary across the choice situations for a respondent. On the other hand, some parameters not included in the MNL models have been included in the ML models. It should be noted that the best-estimated MNL models about the intention to use shared modes offered by the preferred mobility hubs include mode-specific parameters for statements regarding attitudes and social norm. In contrary, generic parameters for statements have been included in the final ML models. This means that the attitude and social norm do not influence the use of one specific shared mode, but rather generally affect the decision to use one of the modes provided by the mobility hub.

The final ML models also include statements regarding attitudes and social norm. The models without statements are included in Appendix D6 & D8. It is concluded that the values of the different parameters included in the models without and with statements do not change significantly. The utility is largely moved from the ASC's to the statements. This implies that the effects of the characteristics in both models are similar. Therefore, it is concluded that the final ML models are robust.

7.3.3 Scenarios

Based on the estimated utilities for the different parameters of mobility hubs (see section 7.3.1 and 7.3.2), the probabilities for the intention to use a specific shared mode can be calculated. This section presents the probabilities for choosing a specific mode in the case of several scenarios. Additionally, the sensitivity in probability due to changes in characteristics is discussed. It should be noted that only trips from the respondent's dwelling with a destination in The Hague are considered.

Walking time and travel costs

The probability of having the intention to use a specific mode is determined by the system, trip, socio-demographic characteristics, attitudes, and social norm. A fictive person (<45 years, high income, living together with children, neutral attitude towards sustainable transport) and trip (visiting, <15 km) have been used to clarify the probabilities and sensitivities due to changes in walking time (Figure 35 and Figure 36) and travel costs (Figure 37 and Figure 38). Moreover, all other system characteristics are fixed. When offering a mobility hub with all shared modes with travel costs of €0.40/km at 3 minutes walking distance, no reservation obligation and unknown users, residents of sample A are more likely to use one of the shared modes, compared to residents of sample B. When increasing walking times, the decrease in the probabilities of shared modes is higher among residents of sample A compared to sample B (Figure 35 and Figure 36).

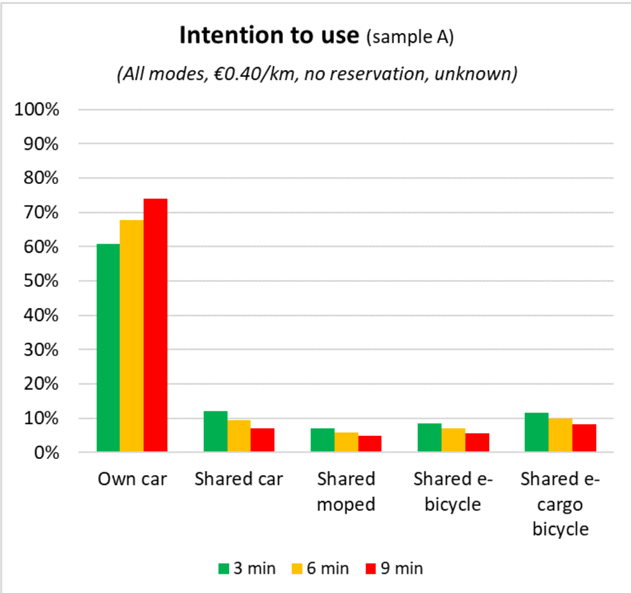

Figure 35: Changes in walking time, sample A

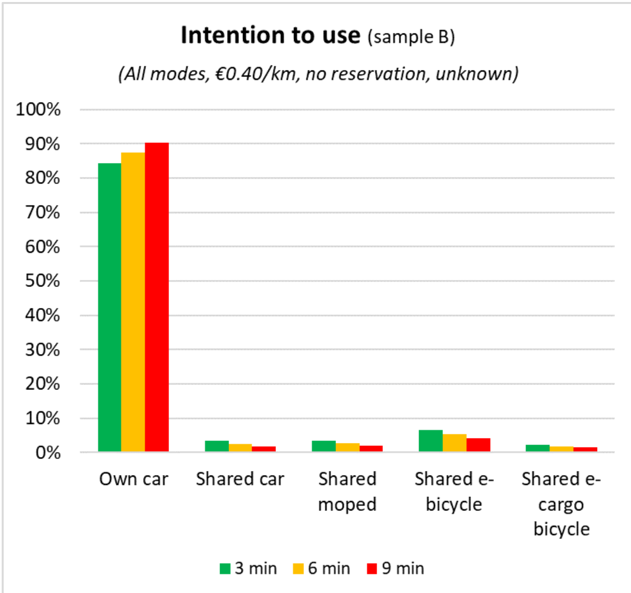

Figure 36: Changes in walking time, sample B

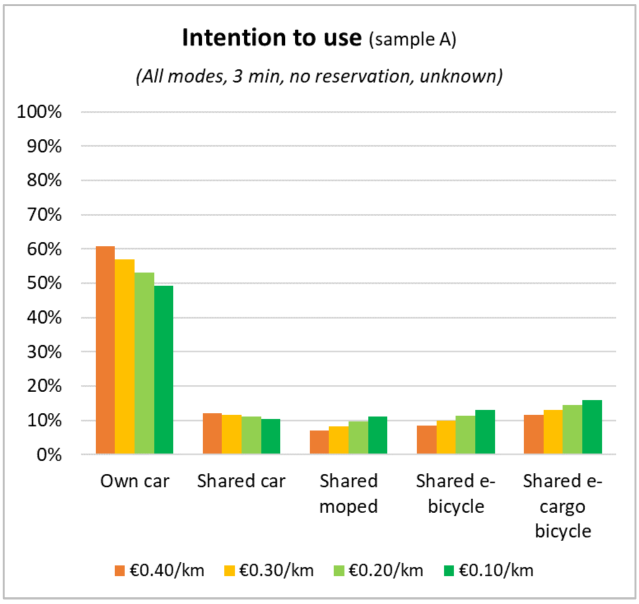

Figure 37: Changes in costs of moped/e-(cargo)bicycle, sample A

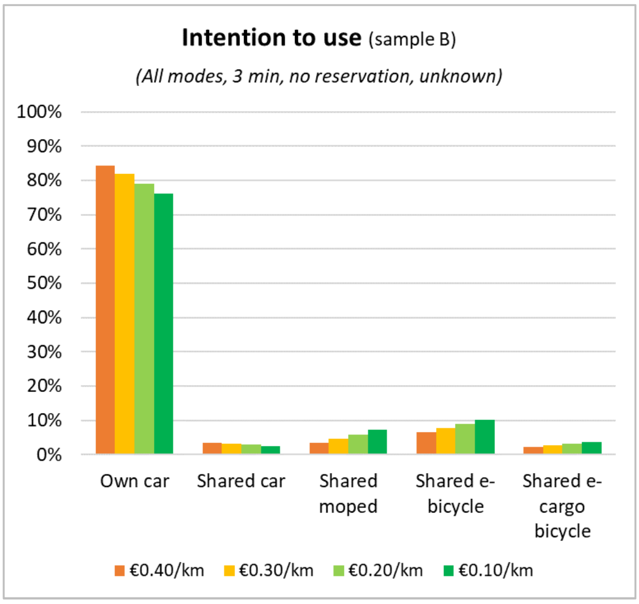

Figure 38: Changes in costs of moped/e-(cargo)bicycle, sample B

When reducing the travel costs of the shared moped and e-(cargo)bicycle, the probabilities of these modes increase (Figure 37 and Figure 38). Accordingly, the probabilities of the own car and the shared car decrease.

Other system characteristics

Besides walking time and travel costs, all other system characteristics can be changed as well (Figure 39 and Figure 40). The walking time (3 minutes) and travel costs (€0.40/km) are fixed in these scenarios. The absence of a car in the mobility hub has most significant effect among residents of both samples. This results in a higher increase in the probability of the own car among residents of sample A compared to sample B. This is caused by the system utilities around 0 in the case of sample A, whereas the system utilities in sample B are more negative. This results in smaller changes in probabilities in sample B, following the Gumbel distribution.

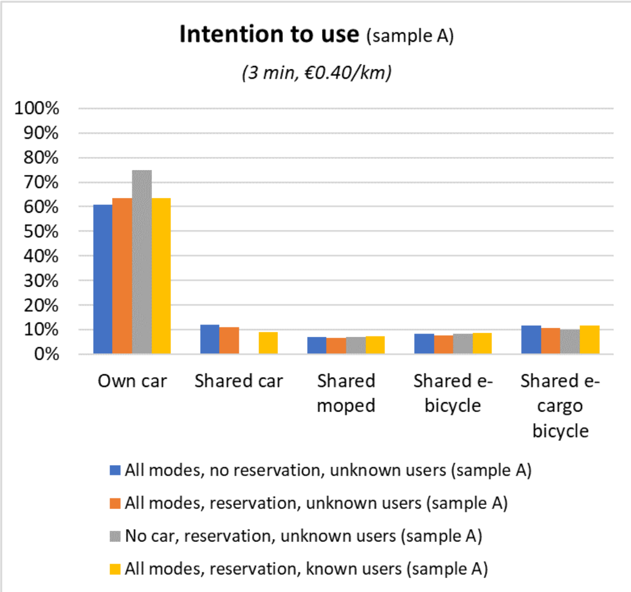

Figure 39: Changes in other system characteristics, sample A

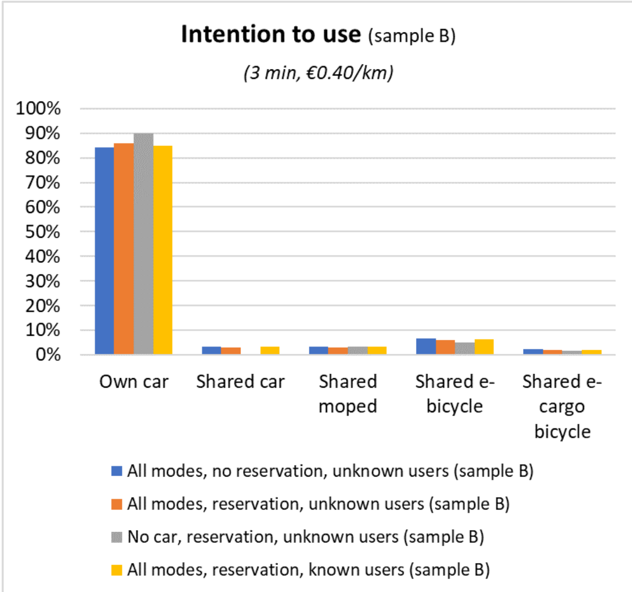

Figure 40: Changes in other system characteristics, sample B

Changes in attitudes

Furthermore, socio-demographic characteristics, attitudes and social norm affect the probabilities of having the intention to use shared modes. In this scenario, it is assumed that the fictive person agrees with statement 2 (I sometimes consider using the bicycle and/or PT instead of the car) and statement 3 (If shared cars would be available anywhere at any time, I do not need my car). Compared to the fictive person without a positive attitude towards sustainable transport use (Figure 39 and Figure 40), the probabilities of the shared modes are considerably higher (Figure 41 and Figure 42).

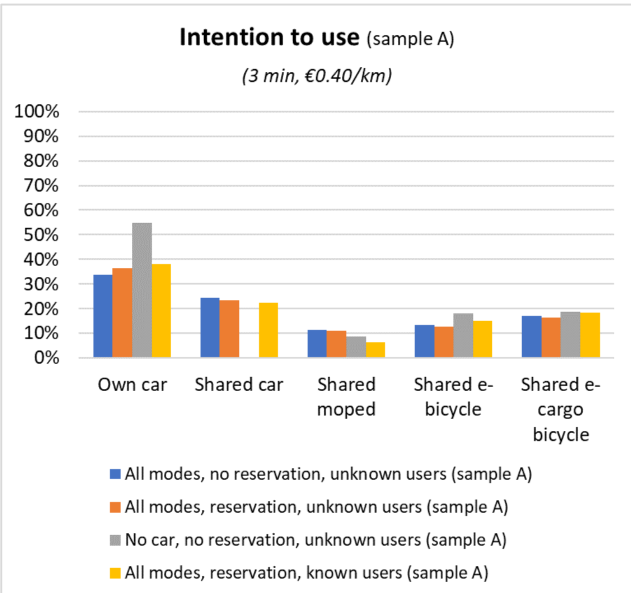

Figure 41: Changes in attitudes, sample A

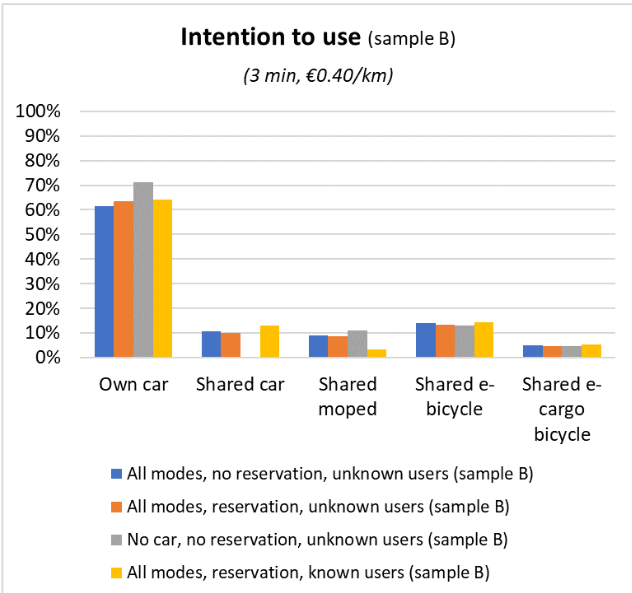

Figure 42: Changes in attitudes, sample B

7.4 Intention to reduce household car ownership

The results regarding the intention to reduce household car ownership when providing mobility hubs in neighbourhoods of sample A and sample B are presented in this section. The potential effect of mobility hubs on household car ownership is presented in the first section. Furthermore, the association between the intention to use and the intention to reduce car ownership, and the association between characteristics and the intention to reduce car ownership are presented in the subsequent two sections. Finally, the possible barriers for inhabitants of the investigated neighbourhoods are presented in the fourth section. The results presented in this chapter answer the following two research questions:

RQ3: What is the potential effect of mobility hubs on household car ownership in the investigated neighbourhoods in The Hague and what characteristics are associated with a reduction in household car ownership when providing mobility hubs in these neighbourhoods?

RQ4: What are the possible barriers for inhabitants of the investigated neighbourhoods to reduce household car ownership when providing mobility hubs in their neighbourhood?

7.4.1 The potential effect of a mobility hub

The intention of the residents to reduce their level of household car ownership has been investigated to measure the change in parking demand in the case that mobility hubs would be provided in their neighbourhood. It should be noted that the respondents have been asked whether they would think about relinquishing their (least used) car when a mobility hub would be provided to their preference in their neighbourhood. Therefore, some caution should be observed when making conclusions about the actual car ownership reduction. Figure 43 shows the intention to reduce car ownership if the mobility hub would be offered to the preference of the resident in their neighbourhood. 20.9% of the residents in Sample A would think about relinquishing their (least used) car, whereas 15.5% of the residents in sample B would think about relinquishing their (least used) car. An explanation could be that residents of the inner-city neighbourhoods (sample A) are more likely to reduce car ownership, because of the availability of a more extensive public transport network, compared to the residents of the VINEX-neighbourhoods (sample B). However, the Chi-square test shows that the reduction is not significantly different between sample A and B on a 95% confidence interval (χ^2=5.861, p=0.053, df=2).

However, one should take into account that households (may) already have had plans to relinquish their car in the current situation. When excluding residents who indicate that they already plan to relinquish a car in the upcoming year (see Figure 44), the reduction in car ownership is already lower: 19.3% in Sample A and 13.2% in Sample B. These results are significantly different between both samples (χ^2=7.466, p=0.024, df=2). When also excluding residents who already may plan to reduce car ownership within one year, the reduction in car ownership is considerably lower: 13.6% in sample A compared to 8.6% in sample B (see Figure 45). The results are not significantly different in both samples (χ^2=5.889, p=0.053, df=2). The weighting of the sample to the population is undesirable as the survey was randomly distributed to households with at least one car (see Appendix D9). Besides, the weighting of the sample would not lead to significantly different results.

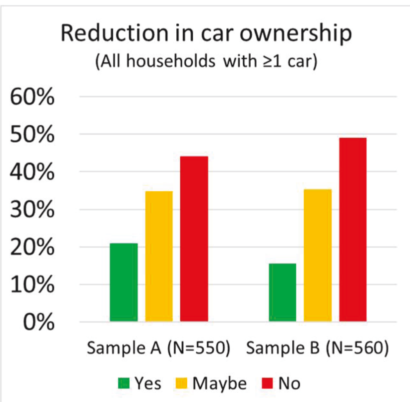

Figure 43: Reduction in car ownership among households with ≥1 car

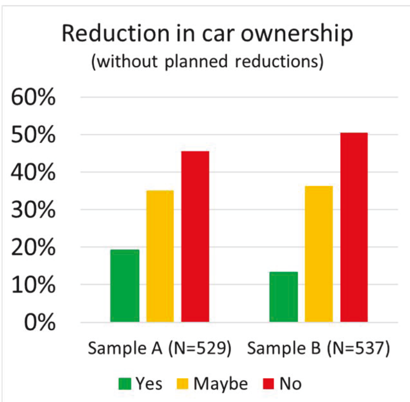

Figure 44: Reduction in car ownership among households without planned reductions in car ownership

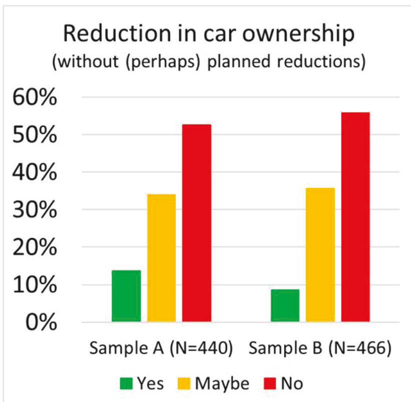

Figure 45: Reduction in car ownership among households without (perhaps) planned reductions in car ownership

Households with more than one car are less likely to relinquish a car in sample A, whereas these households are more likely to relinquish a car in sample B (see Table 18). The results of sample B are as expected based on most previous research. For instance, Münzel, Piscicelli, et al. (2018) and Nijland et al. (2015) found that carsharing primarily replaces a second or third car. Based on the results of this research, it is concluded that this does not apply to the investigated inner-city neighbourhoods of The Hague when providing a mobility hub. Similar findings were found in Amsterdam. According to Municipality of Amsterdam (2019), shared cars do not mainly replace the second or third car among households in Amsterdam.

Table 18: Share of households with plans to relinquish their car when providing the mobility hub

	Sample A (N=440)			Sample B (N=466)		
Household car ownership	**No**	**Maybe**	**Yes**	**No**	**Maybe**	**Yes**
1 car	50.8%	34.8%	14.4%	56.2%	37.3%	6.5%
≥ 1 car	61.1%	29.2%	9.7%	55.3%	33.2%	11.6%

When also taking into the effect of households who (may) refrain from buying an extra car in the upcoming year when a mobility hub would be provided, the potential effect on household car ownership is larger. A large proportion of these households would think about not buying a car in both sample A (45.5%, N=22) and sample B (46.7%, N=30). Thus, the potential effect of a mobility hub is 15.2% in inner-city neighbourhoods compared to 10.9% in VINEX-neighbourhoods (χ^2=3.870, p=0.144, df=2).

Compared to a study into the actual effects of mobility hubs in Würzburg, the potential effects of mobility hubs on car ownership found in this research are relatively large. Pfertner (2017) conducted a survey and found that 15% of the carsharing users (N=84) relinquished a car over the past year. 46% of these users indicated that carsharing had a (very) large influence on this decision. This results in a reduction of 6.9% in which carsharing had a (very) large influence. However, also users with no cars are considered in the study of Pfertner (2017). When excluding users who had never access to private cars (around 50%), it is concluded that the reduction is around 15% among users who had access to a private car. It should be noted that households with at least one car are considered in this research into the potential effects of mobility hubs in The Hague including people who do not have the intention to use the mobility hub. So, the potential reduction would be larger among potential mobility hub users. Therefore, it is concluded that the found potential effect of mobility hubs on car ownership in The Hague is relatively large, which may be caused by the differences in investigated neighbourhoods and the gap between revealed- and stated-preference (Wilke & Bongardt, 2007).

Availability of modes

Residents have been asked to indicate the importance of the different shared modes in a mobility hub (see Figure 46 and Figure 47). Here, only residents with plans to relinquish a car when providing mobility hubs to their preference are considered. The shared car is considered as the most important shared mode in a mobility hub in the decision to reduce car ownership. Besides, the shared e-bicycle is more often assessed as (very) important than (very) unimportant in sample B. The availability of the other modes is found to be less important. However, it should be noted that some residents assess some shared modes as (very) important. Failure to provide these transport modes may result in a lower decrease in the level of household car ownership. When concerning the average value (1=very unimportant, 5=very important) of the individual shared modes in sample A, the shared car ($\bar{x}$=4.50) has the largest average value, followed by shared e-bicycle ($\bar{x}$=2.70), e-cargo bicycle ($\bar{x}$=2.38), and the moped ($\bar{x}$=2.37). The shared car is also the most important mode in sample B ($\bar{x}$=4.39), followed by the shared e-bicycle ($\bar{x}$=3.06), moped ($\bar{x}$=2.51) and the e-cargo bicycle ($\bar{x}$=2.30). It is concluded that the shared e-bicycle is considered as more important among residents of sample B compared to sample A. This may be related to the location of the investigated VINEX-neighbourhoods further away from the other neighbourhoods of The Hague. The shared moped is considered as slightly more important among residents of sample B than sample A, which may be related to the limited supply of shared mopeds in these neighbourhoods (see section 5.1). The drop off zone of the shared moped covers the inner-city neighbourhoods, whereas there is one relatively small drop off zone in the investigated VINEX-neighbourhoods (Felyx, 2019). In contrary, the e-cargo bicycle is considered as less important among residents of the VINEX-neighbourhoods, inherent to the smaller supply in these neighbourhoods. Therefore, it is concluded that the demand for the shared e-cargo bicycle is lower among these residents.

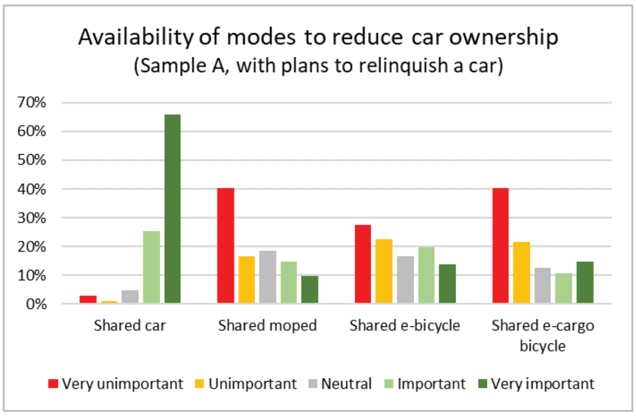

Figure 46: Importance of the availability of shared modes in the decision to reduce car ownership, among households in sample A with plans to relinquish their (least used) car if their preferred mobility hub would be provided in their neighbourhood

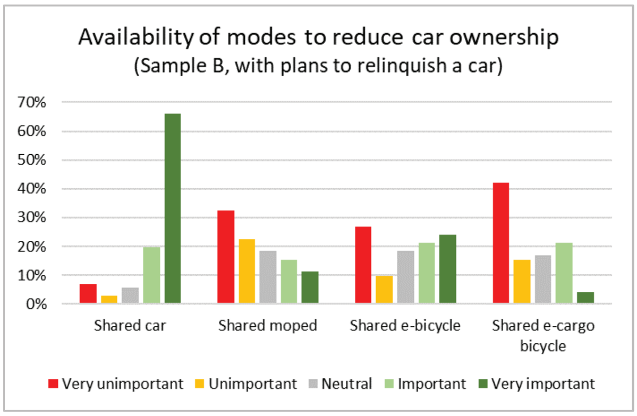

Figure 47: Importance of the availability of shared modes in the decision to reduce car ownership, among households in sample B with plans to relinquish their (least used) car if their preferred mobility hub would be provided in their neighbourhood

Important factors

The residents of both samples have also been asked to indicate how important the different characteristics of a mobility hub are in the decision to reduce household car ownership. Here, only residents with plans to relinquish a car when providing mobility hubs to their preference are considered. The importance of these factors among households who indicate that they would think about relinquishing a car when providing mobility hubs are depicted in Figure 48 and Figure 49. Walking time, costs, return location and reservation time are all considered as important factors, which implies that the mobility hubs should satisfy all these factors in a favourable way to be an attractive alternative to car ownership. When concerning the average value (1=very unimportant, 5=very important) of the individual factors, it is concluded that both travel costs ($\bar{x}$=4.09) and walking time ($\bar{x}$=4.07) and are the most important factors in sample A, followed by return location ($\bar{x}$=3.82), reservation time ($\bar{x}$=3.78), and users ($\bar{x}$=2.51). Regarding residents in sample B, walking time is considered to be the most important factor ($\bar{x}$=4.27), followed by travel costs ($\bar{x}$=4.15), reservation time ($\bar{x}$=3.92), return location ($\bar{x}$=3.89) and users ($\bar{x}$=2.59). Residents of sample B consider all factors to be more important than residents of sample A, as expected, since the potential reduction in car ownership is smaller among residents of sample B. So, the mobility hub in the neighbourhoods of sample B should be more favourable in order to reduce car ownership.

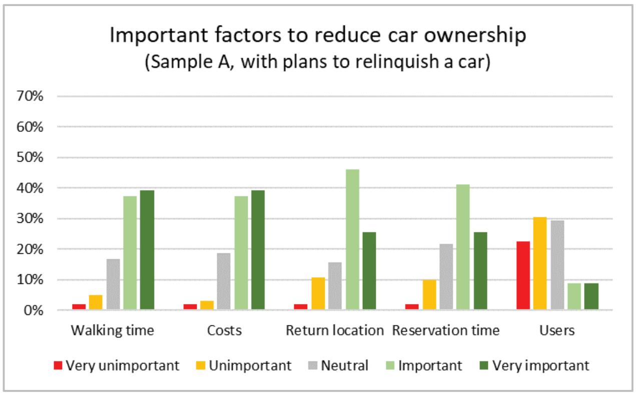

Figure 48: Important factors of a mobility hub in the decision to reduce car ownership, among households in sample A with plans to relinquish their (least used) car if their preferred mobility hub would be provided in their neighbourhood

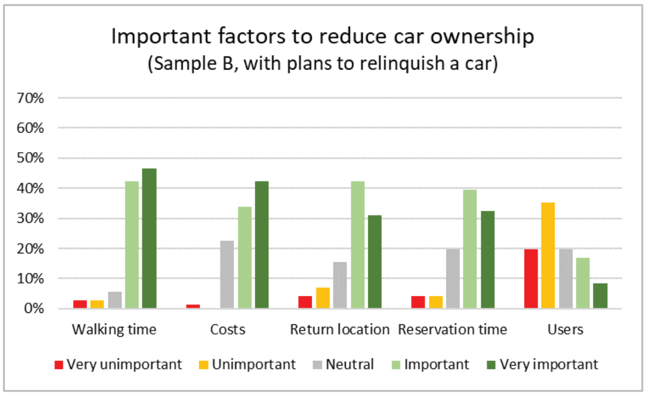

Figure 49: Important factors of a mobility hub in the decision to reduce car ownership, among households in sample B with plans to relinquish their (least used) car if their preferred mobility hub would be provided in their neighbourhood

7.4.2 Association between intention to use & intention to reduce car ownership

The association between the intention to use and the intention to reduce household car ownership has been investigated by comparing the average utility of preferred mobility hubs and the average utility of all mobility hubs with the intention to reduce car ownership. The ML models of the stated choice experiment related to preferred mobility hubs (section 7.3.1) have been used to calculate the average utility. The respondents have been divided into three groups (no, maybe, yes) according to their intention to reduce household car ownership. People who currently indicate that they have plans to relinquish a car without the mobility hub have been excluded in this analysis. An error term for panel effects for every respondent has been drawn twenty times to get more robust results. The results of these twenty draws and the correlation between the average utilities and the intention to reduce car ownership have been summarized in Table 19. More extensive results are attached in Appendix D10.

Residents who experience a higher utility of the mobility hubs in the stated choice experiment are also more inclined to reduce household car ownership. On the contrary, respondents who experience a lower utility of the mobility hubs are less likely to reduce household car ownership. This applies for both the average utility of the preferred mobility hubs as well as for the average utility of all alternatives in the four sets concerning mobility hubs. Both utilities show a weak correlation with the intention to reduce car ownership. The correlation is considerably higher in the neighbourhoods of sample A. This means that residents of investigated inner-city neighbourhoods who experience a high utility in the intention to use the mobility hub for their last car trip to a destination in The Hague are more likely to reduce car ownership in comparison with residents of the investigated VINEX-neighbourhoods.

Table 19: Results of mean of the average of preferred/all alternatives, 20 draws

		Average of preferred alternatives				Average of all alternatives			
Sample		**No**	**Maybe**	**Yes**	**Corr.[a]**	**No**	**Maybe**	**Yes**	**Corr.[a]**
Sample A	**Mean**	**0.09035**	**1.1528**	**1.928**	**0.16835**	**-0.6832**	**0.7456**	**1.2463**	**0.1966**
(20 draws)	S(mean)	0.046721	0.049415	0.082566	0.00658238	0.043352	0.043485	0.055843	0.00516588
Sample B	**Mean**	**0.0492**	**0.8043**	**2.02225**	**0.1395**	**-0.6278**	**0.4961**	**1.44035**	**0.16645**
(20 draws)	S(mean)	0.041974	0.051843	0.071147	0.00553149	0.050779	0.046512	0.061329	0.00548753

*[a] Kendall's tau-b correlation coefficient is based on all individual cases, * $p \leq 0.05$, ** $p \leq 0.01$*

Association between utility of mobility hubs and the probability of relinquishing a car

The association between the utility of the preferred and all alternatives and the potential effect on household car ownership have been further explored. The distribution of residents across the categories of intention to reduce household car ownership (no, maybe, yes) have been investigated for every utility interval. It should be noted that the number of observations differs among the different intervals. Only intervals including at least 20 observations in both samples have been investigated to achieve more robust results.

Regarding the association between the utility of the preferred alternatives and relinquishing a car, it is concluded that the slopes of all categories (no, maybe, yes) are approximately similar across residents of sample A (Figure 50) and sample B (Figure 51). Thus, an increase in utility leads to an approximately similar increase in shares of (maybe) relinquishing a car across both samples. However, the intersection points of the categories no/maybe/yes are at a lower utility in sample A in comparison with sample B. This is caused by the higher average probability of relinquishing a car if the preferred mobility hub would be implemented among residents of sample A. Accordingly, an average utility of the preferred alternatives of more than 2 results in a higher probability of relinquishing a car than not relinquishing a car in sample A. In contrary, an average utility of the preferred alternatives of more than 7 is needed in order to achieve this among residents of sample B. The high probabilities of not relinquish a car at a utility between 0 and 1 can be explained by the high proportion of residents in this utility interval preferring none of the mobility hubs (with utility 0), who accordingly are also less likely to relinquish a car.

The association between the utility of all alternatives and the probability of relinquishing a car is depicted in Figure 52 (sample A) and Figure 53 (sample B). The differences between the graphs of no/maybe/yes are larger compared to the association between the utilities of the preferred alternatives and the probability of relinquishing a car. This is caused by the large number of observations in the interval 0-1 in the case of the preferred alternatives as discussed above. When residents of sample A experienced an average utility between 3 and 4 across all four sets of mobility hubs, the probabilities of no/yes are approximately equal. This intersection point in sample B can be found at a utility of more than 6.

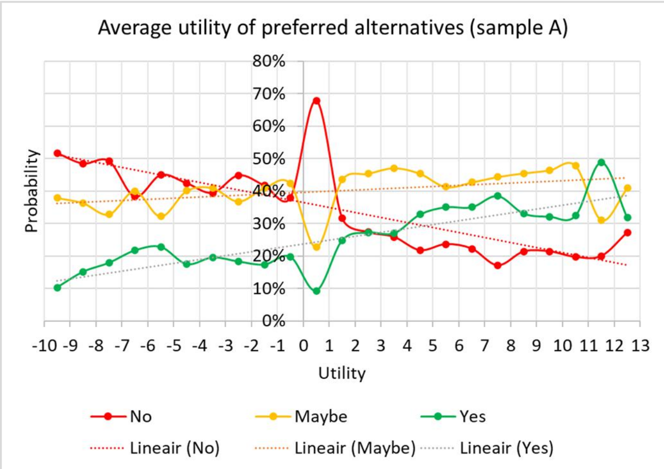

Figure 50: Probabilities of average utility of preferred alternatives, model with attitudes, sample A

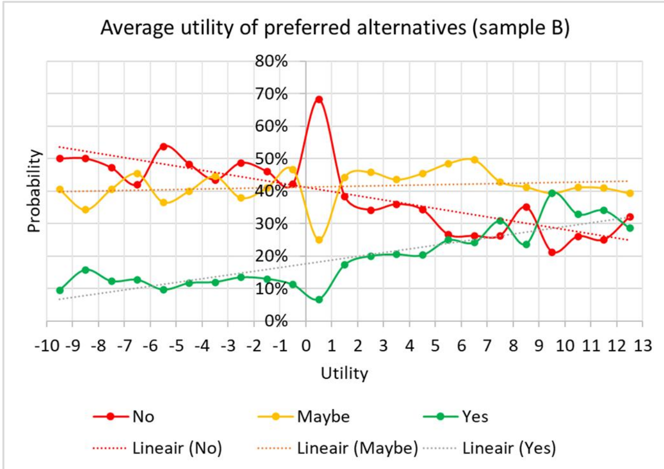

Figure 51: Probabilities of average utility of preferred alternatives, model with attitudes, sample B

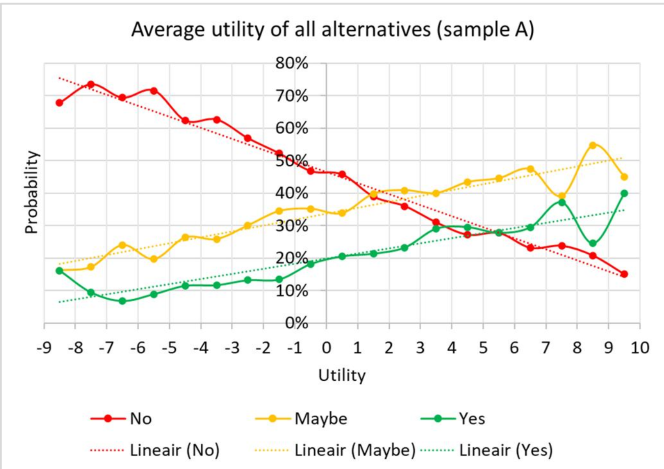

Figure 52: Probabilities of all utility of alternatives, model with attitudes, sample A

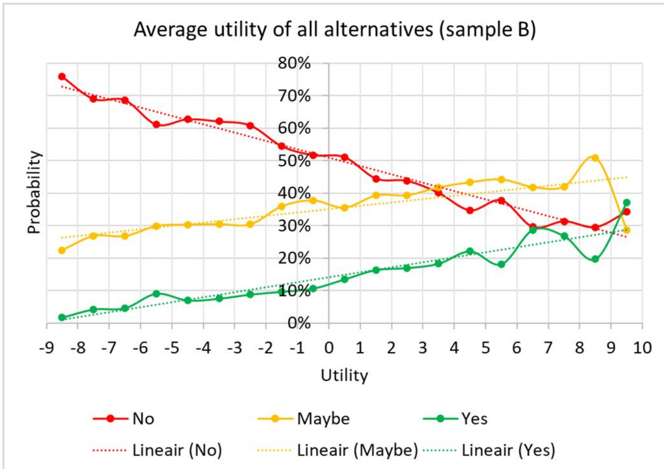

Figure 53: Probabilities of all utility of alternatives, model with attitudes, sample B

Association when excluding the effect of attitudes/social norm

The models about the preferred systems and the intention to use shared modes offered by these systems show a relatively large contribution of the attitudes and social norm on the utility (see section 7.3). Therefore, also the association between the utility of the models without statements regarding attitudes and social norm (Appendix D4) and the intention to relinquish a car has been investigated (see Appendix D11). It is concluded that the slopes of the graphs no/maybe/yes are considerably less steep for the average utility of both the preferred alternatives and all alternatives. This confirms the importance of the attitudes and social norm in the decision to relinquish a car. The remaining slope is caused by the system characteristics (in the case of preferred alternatives), trip and socio-demographic characteristics (preferred and all alternatives). People who experience a relatively high utility based on these characteristics are more likely to relinquish a car, than people who experience a relatively low utility.

7.4.3 Association between variables & intention to reduce car ownership

The association between socio-demographic characteristics, current travel behaviour, attitudes, social norm, and the intention to reduce household car ownership have been investigated, since these factors could influence the intention to reduce household car ownership, according to the theoretical framework. Additionally, the association between the familiarity with current shared mode systems and plans to relinquish a car have been investigated to identify the effect of the familiarity. Households who are planning to relinquish their (least used) car have been removed from the analyses since we are only interested in the reduction in household car ownership due to the mobility hub.

Socio-demographic characteristics & current travel behaviour

It is concluded that older people are less likely to reduce car ownership (Table 20). This corresponds to a study of Prieto et al. (2017), who found that this is due to their stronger attachment to car ownership. Besides, highly educated residents are more likely to relinquish their car in sample A. Households with more cars are more likely to reduce their level of car ownership in sample B, as discussed in section 7.4.1. Latter result is can also be found in various literature studies. For instance, Münzel, Piscicelli, et al. (2018) and Nijland et al. (2015) found that shared cars primarily replace the possession of a second or third car. When considering annual car distances, households who drive smaller annual distances with their (least used) car are more likely to reduce car ownership in sample B. This is as expected since people driving more annual distance are much more dependent on the car and are thus more attached to private car ownership.

When considering current travel behaviour, frequent train users (and bicycle users in sample A) are more likely to relinquish their car, while frequent car users are more likely to keep their car. This corresponds to findings of the adoption of MaaS. For instance, Zijlstra et al. (2019) concluded that frequent public transport users are more likely to be potential users of MaaS. Additionally, frequent car users are less likely to adopt (Ho et al., 2017). Besides, the current use of shared modes also affects the decision to reduce household car ownership in sample A, which indicates that experience with shared modes matters as well. However, the reduction in household car ownership is not significantly associated with current use of shared modes in sample B. The current familiarity with the concept of a mobility hub does not affect the decision to reduce car ownership.

Table 20: Association between socio-demographic variables, current travel behaviour, experience & intention to reduce car ownership

	Sample A (N=529)					Sample B (N=537)				
	Chi-square test			Kendall's tau-b		Chi-square test			Kendall's tau-b	
Variable	df	χ^2 value	p-value	Value	p-value	df	χ^2 value	p-value	Value	p-value
Gender	2	.993	0.609			2	.130	0.937		
Age[a]	4	27.048	0.000	-0.197	0.000	4	11.774	0.019	-0.122	0.001
Education	4	10.990	0.027	0.114	0.005	4	5.005	0.287		
Household income[b]	8	11.820	0.159			8	14.759	0.064		
Number of cars[a]	2	3.323	0.190			2	8.681	0.013	0.090	0.030
Distance (least used) car	10	12.410	0.259			10	22.263	0.014	-0.130	0.000
Frequency of car use[a]	4	25.533	0.000	-0.184	0.000	4	15.269	0.004	-0.124	0.002
Frequency of train use	12	41.933	0.000	0.205	0.000	12	27.205	0.007	0.137	0.000
Frequency of BTM use	12	15.286	0.226			12	17.697	0.125		
Frequency of (e-)bike use[a]	4	19.402	0.001	0.139	0.000	4	3.481	0.481		
Current use of shared modes[a]	4	19.233	0.001	0.154	0.000	4	8.271[c]	0.082[c]		
Known with mobility hub	2	1.271	0.530			2	.288	0.866		

[a] Categories have been merged to meet the requirements of Chi-square test
[b] Category "Do not know/want to say" has been excluded from the analysis
[c] Requirements of Chi-square test have not been met

Statements regarding attitudes and social norm

Table 21 shows that there is an association between all six statements and the intention to reduce car ownership for sample A, whereas this is also the case for three of the statements for sample B. The largest association is between statement 3 and the intention to reduce car ownership. Respondents who agree that they do not need a car when shared cars become available anywhere at any time are more likely to get rid of their car. The correlation coefficients of 0.489 (sample A) and 0.450 (sample B) represent a moderately large association. The association between the other statements and intention to reduce car ownership is relatively small. Residents of sample A who agree that the car gives them freedom are less likely to relinquish their (least used) car. Furthermore, residents of both samples who agree that they sometimes consider using the bicycle and/or PT are more likely to get rid of their car. This effect is stronger in sample B than sample A. Besides, people who agree that they would choose more often for sustainable modes if other people do that as well, are more likely to reduce car ownership. Finally, residents of sample A who agree that their friends think that you should only use the car if needed are more likely to relinquish their car.

Table 21: Association between statements & intention to reduce car ownership

	Sample A (N=529)					Sample B (N=537)				
	Chi-square test			Kendall's tau-b		Chi-square test			Kendall's tau-b	
Variable	**df**	**χ^2 value**	**p-value**	**Value**	**p-value**	**df**	**χ^2 value**	**p-value**	**Value**	**p-value**
S1: The car gives me freedom[a]	4	21.851	0.005	-0.137	0.001	8	13.834	0.086		
S2: I sometimes consider using bicycle and/or PT instead of the car	8	27.479	0.001	0.092	0.021	8	29.902	0.000	0.140	0.000
S3: If shared cars would be available anywhere at any time, I do not need my car	8	200.357	0.000	0.489	0.000	8	160.346	0.000	0.450	0.000
S4: A car says a lot about someone's social status	8	18.126	0.020	-0.029	0.457	8	10.868	0.209		
S5: If other people would choose more often for sustainable modes, I would do that as well.	8	45.487	0.000	0.219	0.000	8	39.398	0.000	0.217	0.000
S6: My friends think you should only use the car if needed	8	25.693	0.001	0.125	0.001	8	11.217	0.190		

[a] *Categories have been merged to meet the requirements of Chi-square test*

7.4.4 Possible barriers for inhabitants to reduce household car ownership

The twenty most important barriers for inhabitants in the decision to relinquish a car when providing a mobility hub to their preference are depicted in Figure 54 (sample A) and Figure 55 (sample B). Freedom of their car and convenience of having your car are the two most important barriers for reducing car ownership. Also, the availability, the flexibility and the independence of the own car are associated with the freedom and convenience of the private car. Therefore, measures to limit the freedom and convenience of private car use may help to reduce car ownership when providing mobility hubs. For instance, parking for own cars can be concentrated in parking garages on central locations in the neighbourhood (Arcadis, 2019). This leads to increasing average distances to their car, which makes the own car less convenient.

Furthermore, the costs of the shared modes provided by the mobility hub are an important obstacle for reducing the level of car ownership. However, costs of the shared car provided in the mobility hub (€0.40/km) are not considerably higher than the costs of private car use of most of the households, assuming a maximum yearly distance of 10,000 km (segment A), 15,000 km (segment B) and even longer distances for the upper segments (see Appendix B1). It is concluded that the high variable cost may form an obstacle for using the shared modes of the mobility hub and the reduction of car ownership.

Besides, some practical issues related to the use of shared modes are found to be among the most important barriers for relinquishing the (least used) car. Holidays and travelling long distances, transport of goods, children, and disabled people, emergencies and necessary for work are potential barriers for residents of both samples. Holidays, travelling long distances and necessary for work result in higher variable costs, as the costs in this research are based on the distance. Transport of goods, children and disabled people may relate to the inconvenience of a walking time towards the mobility hub. Finally, the obstacle emergencies may relate to the uncertainty about the availability of the shared modes and the reservation obligation.

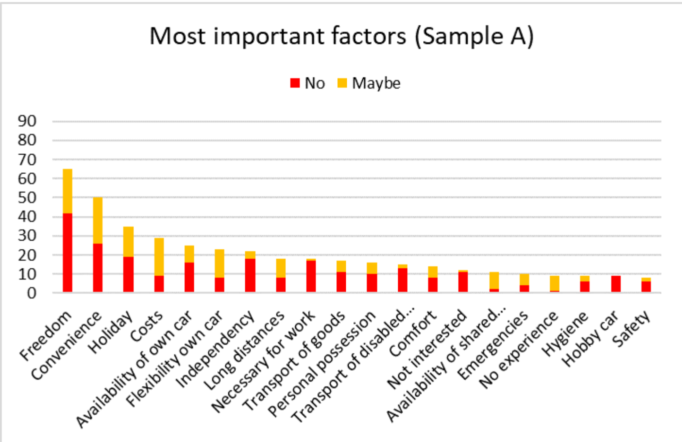

Figure 54: Most important factors for inhabitants of sample A to not think about relinquishing the (least used) car

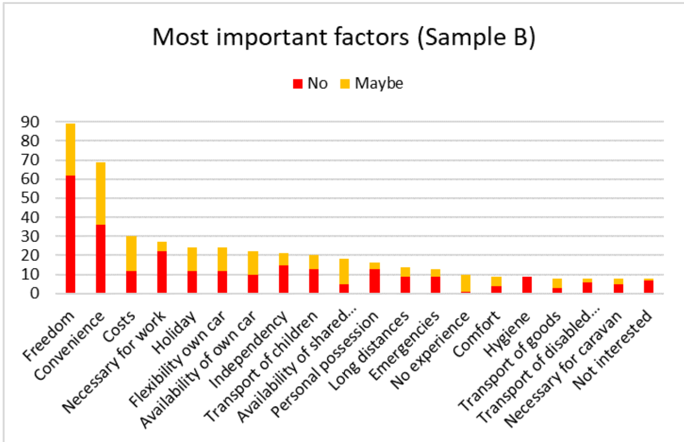

Figure 55: Most important factors for inhabitants of sample B to not think about relinquishing the (least used) car

8 Conclusion & discussion

8.1 Conclusion

This research aims to investigate the characteristics that influence the intention to use shared modes offered by mobility hubs and the potential effect of mobility hubs on household car ownership. Accordingly, the following main research question has been answered:

Main research question: What characteristics influence the intention to use shared modes provided by mobility hubs and what is the potential effect of mobility hubs on household car ownership?

According to the theoretical framework of this research (see section 4), the association between the performance expectancy, effort expectancy, attitudes, social norm and socio-demographic characteristics, and the intention to use shared modes provided by mobility hubs have been investigated. Additionally, the association between the intention to use shared modes and the intention to reduce household car ownership, as well as the association between attitudes, social norm, socio-demographic characteristics, travel behaviour and the intention to reduce household car ownership have been investigated.

The main research question has been answered by conducting a survey in two research areas in The Hague: the inner-city neighbourhoods *Geuzen- en Statenkwartier*, *Bomen- en Bloemenbuurt* and *Vruchtenbuurt* (sample A, N=583), and the VINEX-neighbourhoods *Ypenburg* and *Leidschenveen* (sample B, N=591). All investigated neighbourhoods have an above-average level of household car ownership and a relatively high parking pressure. A relatively high proportion of dwellings in the investigated inner-city neighbourhoods are within the proximity of a shared mode. In contrary, a relatively small proportion of dwellings in the VINEX-neighbourhoods are within the proximity of a shared mode. Moreover, the inner-city neighbourhoods are denser populated compared to the VINEX-neighbourhoods. The main research question is answered by four sub research questions, which are separately discussed below.

RQ1: What are the characteristics of existing shared mode systems and mobility hubs in the Netherlands?

The characteristics of existing shared mode systems and mobility hubs can be divided into characteristics regarding travel costs, travel time, and comfort aspects (see chapter 5). The travel costs vary over the shared modes and suppliers and are mainly based on the usage fees since the registration and subscription fees are relatively low. The total travel time of a shared mode trip includes the access travel time, in-vehicle time, and egress travel time. The access and egress travel time are influenced by the pick-up and return locations of the specific shared modes. By performing a GIS-analysis, access travel times to shared modes have been investigated for all dwellings in The Hague. It is concluded that 33% of the dwellings in The Hague are within 500 meters of a shared car. Besides, this proportion varies considerably over the different neighbourhoods. Based on the GIS-analysis, two research areas have been defined, which differ in the proximity to shared modes. The comfort aspects relate to the system characteristics, availability of the shared modes, the booking application, the users and the included vehicles and their properties.

RQ2: What characteristics influence the intention to use shared modes provided by mobility hubs and to what extent do these characteristics differ between mobility hubs and carsharing systems among residents of the investigated neighbourhoods in The Hague?

The characteristics that affect the choice of preferred carsharing systems and mobility hubs and the intention to use shared modes provided by these systems have been investigated by two stated choice experiments. The characteristics of existing shared modes are included as system characteristics. The experiment about the carsharing systems focused on the last car trip from the respondent's dwelling, whereas the experiment about the mobility hubs focused on the last car trip from the respondent's dwelling to a destination in The Hague. The main conclusions regarding preferred carsharing systems and mobility hubs and the intention to use modes provided by these systems are discussed below. Extensive results can be found in section 7.3.

Preferred systems

The first question in the stated choice experiments focused on preferred carsharing systems and mobility hubs. Respondents were also able to choose for the opt-out option none of the systems. Residents of sample

A are more likely to choose preferred carsharing systems or mobility hubs. Previous research revealed comparable results. For instance, Prieto et al. (2017) concluded that city centre residents are more likely to have the intention to adopt carsharing.

The availability of the shared car in a mobility hub has a larger positive effect among residents of sample A compared to sample B. Reducing the travel costs for carsharing and the travel costs for the shared moped and e-(cargo)bicycle in the mobility hub have a positive effect on the choice of preferred systems. Residents of sample A are more cost-sensitive compared to residents of sample B. Increasing walking times and a reservation obligation have a negative effect on the choice of preferred systems, whereas sharing with known users has a positive effect. The walking time is assessed as equally negative among residents of both samples. Additionally, walking time is found to be more important in the choice of preferred mobility hubs compared to the choice of carsharing systems, related to the considerable smaller average distance in the choice context of mobility hubs. A reservation obligation is more negatively assessed among residents of sample A regarding preferred carsharing systems. However, a reservation obligation is equally important among residents of both samples regarding preferred mobility hubs. Return to pick-up point is more positively assessed than no return needed in the choice of preferred carsharing systems in sample B. The return location does not affect the choice of preferred carsharing systems among residents of sample A and the choice of preferred mobility hubs.

Furthermore, trip, socio-demographic characteristics, attitudes, and social norm affect the decision of preferred systems. The contribution of these characteristics is considerably larger than system characteristics (see section 7.3.1). A mobility hub is more often preferred for work/business-related trips in sample B. Additionally, people between 45 and 65 years and people of 65 years and older are less likely to choose a preferred carsharing system and mobility hub, in accordance with previous research (e.g. KiM (2015)). This effect is even more negative for people of 65 years and older. Higher-income households and one-parent households are more likely to choose a preferred carsharing system in sample A. People living together without children are less likely to choose a preferred mobility hub in sample A.

Attitudes and social norm are most important in the decision for preferred carsharing systems and mobility hubs. These factors are even more important among residents of the VINEX-neighbourhoods investigated in sample B compared to the residents of the inner-city neighbourhoods investigated in sample A. Residents with a positive attitude towards shared cars and sustainable transport are more likely to choose a preferred system. Statement 3 (If shared cars would be available anywhere at any time, I do not need my car) is the most important determinant. Statement 2 (I sometimes consider using the bicycle and/or PT instead of the car) and statement 5 (If other people would choose more often for sustainable modes, I would do that as well) are strong determinants among residents of sample B. Statement 5 is also important in the choice for preferred mobility hubs among residents of sample A. Furthermore, statement 4 (A car says a lot about someone’s social status) is important in the choice for preferred carsharing systems in sample A and preferred mobility hubs in sample B. It should be noted that there is also a correlation in the choices of the same respondent (panel effects). This indicates that some residents experience a relatively high utility with preferred systems, while other residents experience a relatively low utility with preferred systems.

Intention to use shared modes

The second question in the stated choice experiment focused on the intention to use shared modes offered by the preferred carsharing system or mobility hub. Residents of both samples are more likely to use their car than the shared modes offered by the preferred carsharing systems and mobility hubs, if they would make their last car trip from their dwelling (to a destination in The Hague) again. Residents of sample A are more likely to use the shared modes offered by the preferred systems, in comparison with residents of sample B. Therefore, it is concluded that the mobility hubs are potentially more successful in the investigated neighbourhoods than the investigated VINEX-neighbourhoods. Residents of both samples are most likely to use the shared car among all the shared modes offered by the preferred mobility hubs. The other shared modes are suitable for specific situations, given the high standard deviation in the error term. This implies that the added value of the mobility hub over a carsharing system is limited.

Compared to results of preferred systems, a relatively small number of system characteristics affects the intention to use shared modes. However, the intention to use shared modes was only investigated for preferred systems. Therefore, the results presented here should be considered together with the discussed results of preferred systems. Travel costs and walking time are the only two generic system characteristics that affect the choices between the own car and the shared modes offered by the preferred systems. The importance of travel costs is also found by Duncan (2011), who concluded that the key element for the potential growth of sharing is the ability to provide cost savings. Reducing the travel costs for the shared car in the preferred carsharing systems positively affects the intention to use shared cars. The same applies to the preferred mobility hubs. Reducing the travel costs of the shared moped and e-(cargo)bicycle positively affects the use of these modes. Additionally, increasing walking times negatively affect the intention to use the shared modes offered by the preferred systems. Besides, sharing with known users negatively affects the intention to use shared cars of preferred mobility hubs. Furthermore, it is concluded that residents of sample A are more sensitive for longer walking times to mobility hubs and less cost-sensitive for the shared moped and e-(cargo)bicycle, compared to residents of sample B.

Trip, socio-demographic characteristics, attitudes, and social norm also affect the intention to use shared modes. It is concluded that the effect of these characteristics is again larger than the effect of the system characteristics. Residents of sample B are more likely to use the shared modes of preferred mobility hubs for unregular trips (<1 day/week). This is supported by previous research. For instance, KiM (2015) concluded that the shared car is most often used for unregular trips among Dutch carsharing users. Residents of sample A are less likely to use the shared moped and e-bicycle for longer trips (>15 km). Furthermore, residents of sample B are more likely to use the shared moped for working/business-related and visiting trips. The effect regarding visiting trips is also found in the results of the intention to use the shared car of the preferred car sharing systems among residents of sample B. This is confirmed by previous research. KiM (2015) concluded that shared cars are more often used for visiting purposes. Besides, it is concluded that the intention to use the shared car of a preferred carsharing system for shopping trips is smaller among residents of sample A.

High-income households are more likely to use the shared moped among residents of sample A. People living together with children in sample A are more likely to use the shared e-cargo bicycle, inherent to the transport characteristics of the e-cargo bicycle: the ability to transport children. It is concluded that the intention to use shared modes is mainly explained by attitudes and social norm. Many studies confirmed that attitudes and social norm are an important determinant for the intention to use (Ajzen, 1991; Dwivedi et al., 2019). Statement 3 (If shared cars would be available anywhere at any time, I do not need my car) is the most important attitude. Residents who agree with this statement are positively associated with the intention to use shared modes in both samples. Furthermore, residents of sample A who agree with statement 1 (The car gives me freedom) are less likely to use shared cars of preferred carsharing systems and shared modes of preferred mobility hubs. Residents of sample B who agree with statement 5 (If other people would choose more often for sustainable modes, I would do that as well) are more likely to use shared modes of the preferred mobility hub. The same applies to residents of sample A in the case of preferred carsharing systems. Residents of sample B who agree with statement 2 (I sometimes consider using the bicycle and/or PT instead of the car) are more likely to have the intention to use shared cars provided by preferred carsharing systems.

RQ3: What is the potential effect of mobility hubs on household car ownership in the investigated neighbourhoods in The Hague and what characteristics are associated with a reduction in household car ownership when providing mobility hubs in these neighbourhoods?

The potential effect of a mobility hub is a reduction of 19.3% in sample A and 13.2% in sample B when excluding the residents who already had plans to relinquish their (least used) car before the implementation of the mobility hub. The potential reduction is considerably smaller when excluding the residents who already had plans to perhaps relinquish their (least used) car: 13.6% in sample A and 8.6% in sample B. Households with more than one car in sample B are more likely to relinquish a car compared to households with one car. This is supported by previous literature studies, which concluded that carsharing primarily replaces a second or third car (Münzel, Piscicelli, et al., 2018; Nijland et al., 2015). However, this is not the case for residents of sample A. It is concluded that the potential effect is a reduction of 15.2% in sample A and 10.9% in sample B, when incorporating the unobserved effects of residents who refrain from purchasing an extra car. The results are not significantly different among residents of both samples. Compared to a study into the actual effects of carsharing users of mobility hubs in Würzburg (Pfertner, 2017), the potential effect found in this research is relatively large (see section 7.4.1). The actual effect in Würzburg is a car ownership reduction of around 15% among carsharing users who had access to a private car. However, also people who do not have the intention to use the mobility hub are considered in the potential reduction found in this research. Therefore, it is concluded that the found potential effect in this research is relatively large. This may be caused by the differences in investigated neighbourhoods as well as the gap between revealed- and stated-preference. Moreover, the mobility hub should be provided to the respondents' preferences (in terms of most important provided shared modes and beneficial factors) in order to achieve the potential effect.

The availability of the shared car in the mobility hub is most important mode in the decision to reduce car ownership among residents of both samples, followed by the shared e-bicycle. The moped is the least important shared mode in a mobility hub in sample A, whereas the e-cargo bicycle is the least important shared mode in sample B. The shared e-bicycle is assessed as more important in sample B than sample A. Regarding the mobility hub characteristics, walking time and travel costs are equally important in the decision to reduce household car ownership in sample A, followed by return location, reservation time and users. Walking time is considered as the most important factor in sample B, followed by travel costs, reservation time, return location and users.

Regarding the theoretical framework, the association between the intention to use and intention to reduce car ownership has been investigated. It is concluded that residents who experience a higher average utility in the decision between preferred mobility hubs are also more likely to relinquish the (least used) car. In contrary, residents who experience a lower utility are less likely to relinquish the (least used) car. However, it should be noted that the correlation coefficient is relatively low. Furthermore, it is concluded that residents of sample A are more inclined to reduce household car ownership if they experience a higher utility, compared to residents of sample B.

Attitudes, social norm, socio-demographic characteristics, and travel behaviour affect the intention to reduce household car ownership. Older people are less likely to relinquish their (least used) car in both samples. Higher educated people in sample A are more likely to get rid of their car. Prieto et al. (2017) also concluded that younger people and higher educated people are positively associated with higher carsharing intention. Households with more than one car are more likely to reduce household car ownership in sample B. This corresponds to previous research concluding that carsharing primarily replaces the second and third car (Münzel, Piscicelli, et al., 2018; Nijland et al., 2015). Additionally, households with a smaller annual distance with their (least used) car are more likely to relinquish their car in sample B. People who use car more frequently are less likely to reduce car ownership, whereas people who use the train (or bicycle in sample A) more frequently are more likely to reduce car ownership. Residents in sample A who currently use shared modes more often are also more likely to reduce car ownership.

RQ4: What are the possible barriers for inhabitants of the investigated neighbourhoods to reduce household car ownership when providing mobility hubs in their neighbourhood?

It is concluded that freedom and convenience of the own car are the most important factors to not relinquish the (least used) car. Additionally, availability, flexibility and independence of the private car are also among the most mentioned barriers. Furthermore, the costs of the shared modes provided by the mobility hub are an important obstacle for the reduction of household car ownership, although the total costs of the shared modes provided by mobility hubs are not too high compared to costs of private car ownership. Therefore, it is concluded that high variable costs of shared modes may form an obstacle for reducing household car ownership. Additionally, there are some practical issues which may form a barrier to relinquish their (least used) car. Holidays and travelling long distances, transport of goods, children and disabled people, emergencies and necessary for work are among the twenty most important obstacles among residents of both samples.

8.2 Discussion

This research aimed to investigate the characteristics that influence the intention to use shared modes provided by mobility hubs, as well as the potential effect of mobility hubs on household car ownership. The results have been retrieved by conducting a survey in two specific research areas in The Hague: Geuzen- en Statenkwartier, Bomen- en Bloemenbuurt and Vruchtenbuurt on the one hand (sample A), and Ypenburg and Leidschenveen on the other hand (sample B). The minimum required sample size of 377 households has been satisfied in both research areas (Survey Monkey, 2019). The survey was randomly distributed to households with at least one car since this research aimed to investigate the potential effect of mobility hubs on household car ownership. Accordingly, these households are overrepresented when comparing the samples to the populations of investigated neighbourhoods (see section 7.1). Furthermore, one should consider the self-selection bias, which might be introduced by asking people through distributed letters to complete a survey about shared modes. Residents who are not interested in shared modes might be less likely to complete the survey. Therefore, some caution should be exercised by consultation of the survey results.

The main results are based on stated-preference data retrieved by a survey distributed among residents of investigated neighbourhoods. As commonly known, stated-preference data is less reliable than revealed-preference data because they do not reflect actual choices (Train, 2009). However, revealed-preference data are limited "to the choice situations and attributes of alternatives that currently exist or have existed historically" (Train, 2009). Since mobility hubs are currently only implemented through pilots, a survey was the most suitable medium to investigate the effects of mobility hubs with different characteristics.

Several ways were used to increase the reliability of the stated-preference survey. Firstly, the choice experiments about the preferred characteristics and the intention to use the modes provided by carsharing systems and mobility hubs were asked before investigating the potential effect on household car ownership. In this way, the respondent was able to assess the added value of a mobility hub for him/her before deciding on a more difficult decision (the intention to reduce car ownership). Secondly, the choice experiment about the carsharing systems was asked before the choice experiment about the mobility hubs to gradually build up the difficulty of the choice experiments and to assess the added value of a mobility hub over a carsharing system. Thirdly, the stated choice experiments focused on specific trips of the respondent to enhance choice context and to make the respondent able to make more realistic choices in terms of preferred systems and modes for the specific trip. The choice experiments about the carsharing systems focused on the last car trip from the respondent's dwelling. The choice experiments about the mobility hubs focused on the last car trip from the respondent's dwelling to a destination in The Hague. The last car trip to a destination in The Hague was used to provide the respondent with a realistic choice context since the mobility hub consists of shared modes which are only of added value for short trips. Trip characteristics of the trips were asked to investigate the effect of trip characteristics on the intention to use. However, it should be noted that the influence of external variables (e.g. weather circumstances, parking costs, delays) have not been investigated. Lastly, the attributes in the choice sets of the carsharing systems and mobility hubs were limited and simplified to find a trade-off between the difficulty level of the choice context and to investigate the effects of the most important characteristics.

The simplification of the attributes also has some drawbacks. The travel costs of the shared car in the choice experiment about the mobility hub were fixed at €0.40/km. As a result, the trade-offs between travel costs of the shared car and other characteristics have not been investigated. However, the effects of changing the travel costs of the shared moped and e-(cargo)bicycle (and relative to the costs of the shared car) have been investigated. Furthermore, this research does not provide insight into the effects of subscription costs (€/month) in return for lower travel costs (€/km), as the number of respondents with plans to buy an extra car (N=20 in sample A and N=30 in sample B) is too small to estimate models with significant parameters. The inclusion of subscription costs in the stated choice experiments of all respondents could give insight into these effects. However, this may result in a more limited number of attribute levels of other important characteristics as well as less significant cost parameters. Overall, this research provides insight into the trade-offs of the most important carsharing and mobility hub characteristics in the context of car trips. The effects of providing carsharing systems and mobility hubs on trips made by other transport modes was beyond the scope of this research aimed at investigating the potential effect on car ownership and are unknown.

The probabilities of having the intention to use shared modes offered by the mobility hub were calculated for several scenarios. Assumed is that respondents choosing "None" instead of one of the preferred mobility hubs would use their car. However, respondents may experience an equally high preference for both mobility hubs, resulting in a preference for "None". As a result, these respondents might prefer shared modes over their car. Thus, the probabilities of having the intention to use a shared mode might be higher. The exact probabilities could be calculated when excluding the opt-out option "None". However, this could lead to a forced decision between the two mobility hubs, whereas the respondent might be equally or not interested in both mobility hubs. Therefore, the inclusion of the opt-out option was assessed as more important in the research into the trade-offs of the characteristics, rather than the calculation of the exact probabilities.

This research was aimed at investigating the potential effect of a mobility hub on household car ownership. However, deciding on relinquishing a car without first experiencing the new concept of a mobility hub is a difficult decision. Therefore, the question was asked more carefully: "would you think that you would relinquish a car" instead of "are you going to relinquish the car". Besides, the effect was investigated in the context of providing a mobility hub to the preference of the respondent. Consequently, the potential effect of a mobility hub was investigated rather than the actual effect of a mobility hub. In comparison with the actual effects of mobility hubs on car ownership in Würzburg (Pfertner, 2017), the potential effect on car ownership found in this research is relatively large. Wilke and Bongardt (2007) concluded that the realistic potential for carsharing is lower than the theoretical potential given the gap between attitude and behaviour. Therefore, it is expected that the actual effect of mobility hubs in The Hague would be smaller.

The theoretical framework of this research is based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and Theory of Planned Behaviour (TPB). The theoretical framework assumes that performance expectancy, effort expectancy, attitudes, social norm and socio-demographic characteristics influence the intention to use (chapter 4). It is assumed that this effect as well as the effect between the intention to use and use are unidirectional, similarly to the UTAUT and TPB. Possible reverse-causal effects, such as the effect of (intention to) use on attitudes, are ignored. Several studies show the existence of those reverse-causal effects (Sussman & Gifford, 2019; Van Wee et al., 2019). For instance, Van Wee et al. (2019) concluded that people may change their attitudes due to new experiences and mismatches between attitudes and travel behaviour. Therefore, it is recommended to consider the investigation of these reverse-causal effects in further research.

Considering the models about the intention to use mobility hubs, the ASC of the investigated inner-city neighbourhoods is larger than the ASC of the investigated VINEX-neighbourhoods. This implies that other characteristics not incorporated in the theoretical framework of this research affect the intention to use shared modes. The association between the familiarity with shared modes and the intention to use has shortly been analysed. It is concluded that the explanatory power of the models does not improve. The difference between the investigated neighbourhoods may be explained by other attitudes not investigated in this research such as built environment characteristics of the neighbourhoods. Based on this research, it cannot be explained which factors determine the difference between the ASC's of both neighbourhoods.

Implementation in The Hague

The results of this research can be used by the further elaboration of the policy of the Municipality of The Hague on the implementation of mobility hubs in their neighbourhoods. The results are directly applicable to the neighbourhoods considered in this research: *Geuzen- en Statenkwartier, Bomen- en Bloemenbuurt, Vruchtenbuurt, Ypenburg* and *Leidschenveen*. Since the attitudes and social norm are not always known to the Municipality, the results of the models without statements are presented in Appendices D2, D4, D6 and D8. In this way, the potential effects of mobility hubs can still be calculated – albeit less effectively – without considering the attitudes and social norm.

The results of this research show the importance of attitudes and social norm in the decision to have the intention to use shared modes provided by mobility hubs and the decision to have the intention to relinquish the (least used) car. In order to achieve larger effects, it is recommended to implement the mobility hubs in neighbourhoods *(wijken/buurten)* with a high share of residents with positive attitudes towards shared cars and sustainable transport modes. Besides, the age of the residents of specific neighbourhoods should be considered as well, since younger people (<45 years) are more likely to use shared modes provided by mobility hubs and relinquish a car. Here, insight into the geographical segmentation of attitudes, social norm and age of the residents is important to implement the mobility hubs more effectively.

The effects of mobility hubs with specific characteristics on the use of the mobility hub can be estimated by using the results presented in this research (chapter 7), based on the distribution of attitudes, social norm and socio-demographic characteristics of the population. The probabilities of choosing specific shared modes provided by the mobility hubs can be calculated for specific population groups. Based on the shares of population groups in specific neighbourhoods, the average probability of choosing specific shared modes can be calculated. The desirable characteristics of mobility hubs can be tailored based on trade-offs between the population share that is willing to use the mobility hubs, the objectives of the Municipality and the costs for the implementation of the mobility hubs.

As discussed, the actual effect of mobility hubs on household car ownership would be lower than the presented potential effects. Therefore, it can be concluded that the implementation of the mobility hubs has a limited effect on household car ownership in The Hague. The Municipality of The Hague has the policy to intervene if the parking pressure exceeds 90% due to limited urban parking space (Municipality of The Hague, 2011). The introduction of a progressive licensing policy, whereby the license for the first car is cheaper than subsequent car(s) is part of this. Due to the limited potential effect of mobility hubs on car ownership, it is recommended to implement mobility hubs in combination with other car restrictive measures (e.g. used licensing policy, paid parking) to achieve larger effects on household car ownership.

The results of this research are specifically applicable to the investigated neighbourhoods in The Hague. These results cannot directly be generalized for other neighbourhoods in and outside The Hague without considering differences in the supply of existing shared mode systems, the built environment and transportation characteristics of the investigated neighbourhoods and the neighbourhoods considered in this research. The different results of inner-city neighbourhoods considered in sample A and the VINEX-locations considered in sample B confirm that the effects differ across neighbourhoods with different characteristics. Therefore, it is recommended to compare these characteristics to better interpret the results and to implement the mobility hubs more effectively.

Recommendations

Further research could focus on the investigation of the most important characteristics that influence the intention to use shared modes provided by mobility hubs and the intention to reduce household car ownership in other neighbourhoods in and outside The Hague. This could provide more insight into the relation of the built environment and transportation characteristics of the neighbourhood, and the potential effect of mobility hubs so that municipalities can implement the mobility hubs even more effectively. Additionally, research into the trade-offs of subscription costs in return for lower variable costs and variable costs only can provide insight in the importance of offering subscriptions.

Future research could also focus on the effects of providing mobility hubs in combination with car restrictive measures, such as increasing parking costs and parking for private vehicles further away, in line with the limited potential effect on car ownership when offering mobility hubs. Additionally, research into the intention to use of mobility hubs in the context of other transport modes than the car is needed to assess about the economic viability of mobility hubs. Furthermore, research into the effects on car use, which was beyond the scope of this research, is recommended to provide insight into the effects in terms of emissions.

Finally, it is recommended to implement mobility hubs with different characteristics to investigate the actual effects of mobility hubs, considering the gap between revealed- and stated-preference research. The importance of the mobility hub characteristics investigated in this research can be used, when designing and implementing the mobility hubs. Subsequently, short term (use) and long term (car ownership) effects can be measured more effectively without implementing all forms of mobility hubs.

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Appendices

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Appendix A: Analysis of existing shared mode systems in The Netherlands

Appendix A1: Household car ownership and suppliers of existing shared mode systems

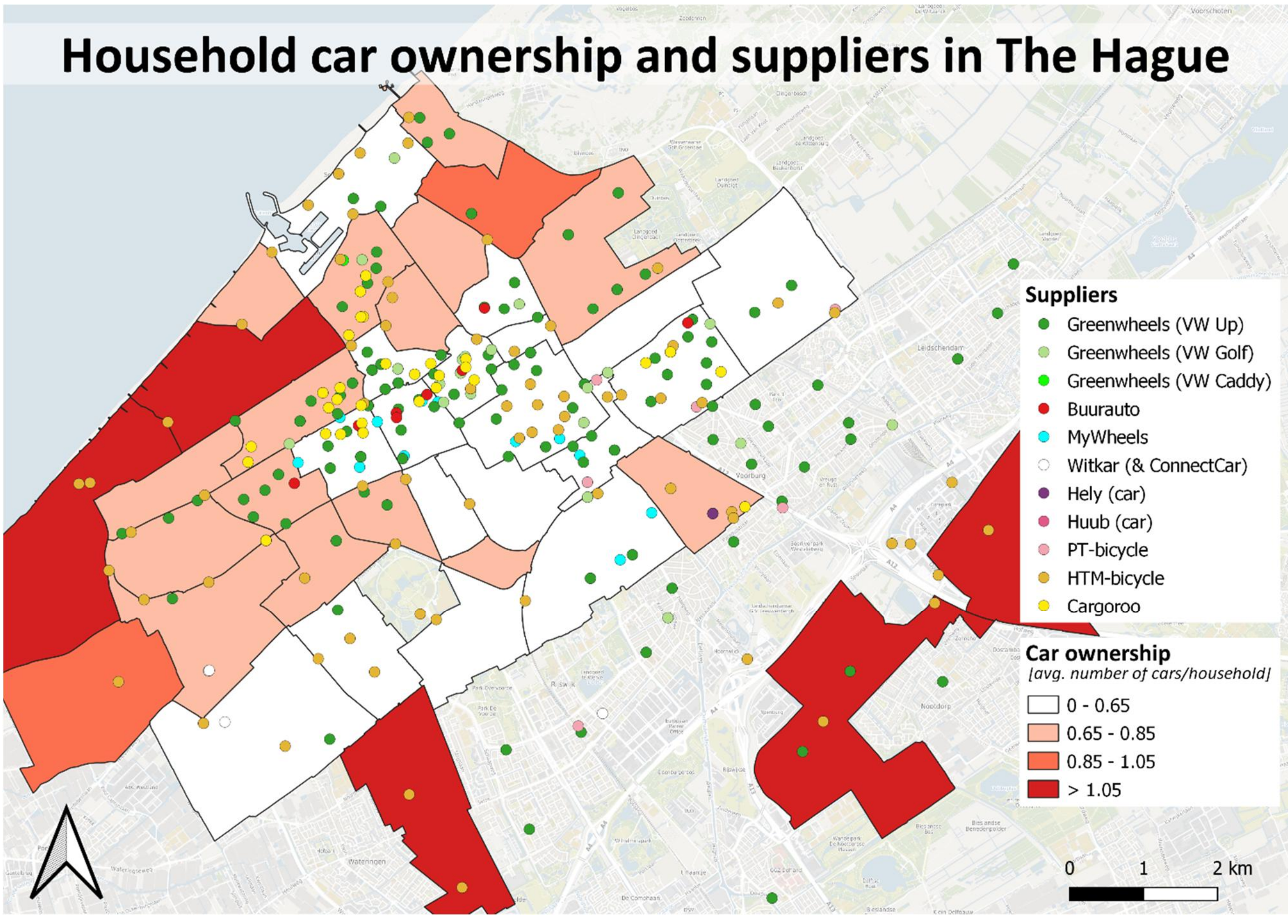

Figure A1: Overview of household car ownership (Municipality of The Hague, 2019) and shared modes in The Hague (except Felyx & MoBike), based on (Buurauto, 2019; Cargoroo, 2019; ConnectCar, 2019; Greenwheels, 2019; Hely, 2019; HTM, 2019; MyWheels, 2019; NS, 2019; Witkar, 2019)

Appendix A2: Overview costs of shared mode systems

Table A1: Overview of costs of existing shared mode systems in the Netherlands, information retrieved from (Buurauto, 2019; Car2Go, 2019; Cargoroo, 2019; ConnectCar, 2019; Donkey Republic, 2019; Felyx, 2019; Fetch, 2019; GoSharing, 2019; Greenwheels, 2019; HTM, 2019; JUMP, 2019; Mobike, 2019; MyWheels, 2019; NS, 2019; Witkar, 2019)

	Greenwheels			MyWheels	ConnectCar	Buurauto				Car2Go	Witkar	Fetch	Felyx	GoSharing
Shared mode	Car			Car	Car	Car				Car	Car	Car	E-moped	E-moped
Registration fee	€ 0			€ 0	€ 25	€ 0 (a)				€ 9 (a)	€ 25	€ 10 (a)	€ 8.40 (a)	€ 0
Subscription	A	B	C			A	B	C	D					
€/month	€ 0	€ 10	€ 25	€ 0	€ 0	€ 0	€ 15	€ 35	€ 70	€ 0	€ 0	€ 0	€ 0	€ 0
Usage costs														
€/time	€ 0	€ 0	€ 0	€ 2.50	€ 3.50	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Vehicle type 1	VW Up			Peugeot108 Citroën C1	Smart	BMW i3 Nissan Leaf 40 kW				Smart	Smart	Renault ZOE		
€/min	-	-	-	-	-	-	-	-	-	€ 0.31 (b)	€ 0.3	€ 0.30 (c)	€ 0.30 (d)	€ 0.29 (d)(e)
€/hour	€ 6	€ 4	€ 3	€ 2.50	€ 3.05 (g)	€ 2	€ 1	€ 0.50	€ 0.25	€ 15.60 (h)	€ 18	€ 15.60	-	-
€/day	€ 49	€ 39	€ 29	€ 25	-	-	-	-	-	€ 79 (h)	€ 54	€ 78	-	-
€/km	€ 0.34	€ 0.29	€ 0.24	€ 0.27	€ 0.26	€ 0.60	€ 0.50	€ 0.40	€ 0.30	€ 0.00 (j)	€ 0.00 (k)	€ 0.00 (l)	€ 0.00	€ 0.00
€/km (100+ km)	-	-	-	-	€ 0.13	-	-	-	-	-	-	-	-	
Vehicle type 2	VW Golf / VW Caddy			Opel Corsa Renault ZOE	Opel Zafira	Nissan Leaf 30kW								
€/hour	€ 7.50	€ 5.50	€ 4.50	€ 4	€ 4.27 (g)	€ 2	€ 1	€ 0.50	€ 0.25					
€/day	€ 59	€ 49	€ 39	€ 25										
€/km	€ 0.39	€ 0.34	€ 0.24	€ 0.12	€ 0.35	€ 0.50	€ 0.40	€ 0.30	€ 0.20					
€/km (100+ km)				€ 0.27	€ 0.17									
Vehicle type 3	VW e-Golf			Citroën C3										
€/hour	€ 11	€ 9	€ 8	€ 2.75										
€/day	€ 89	€ 79	€ 69	€ 27.50										
€/km	€ 0.20	€ 0.15	€ 0.12	€ 0.29										
Vehicle type 4				Nissan Leaf										
€/hour				€ 2										
€/day				€ 20										
€/km				€ 0.20										

	Cargoroo	JUMP	Donkey	Mobike	NS	HTM
Shared mode	C-bicycle	E-bicycle	Bicycle	Bicycle	Bicycle	Bicycle
Usage costs						
€/time	€ 1	€ 1	€ 0	€ 0	€ 0	€ 0
Vehicle type 1						
€/min	€ 0.06	€ 0.20	-	€ 0.05 (f)	-	-
€/hour	€ 3.50	-	€ 3.30 (i)	-	-	€ 2
€/day	€ 20	-	€ 13 (i)	-	€ 3.85	€ 5

(a) € 15 (Car2Go), half hour of free driving (Fetch and Felyx) in return; free driving of max. 50 km / 10h (Buurauto)
(b) Costs of Car2Go dependent on the supply at the start of rental: € 0.26/min - € 0.36/min
(c) Costs after 1 hour: € 0.26/min
(d) Costs parked e-moped: € 0.10/min (Felyx), € 0.05/min (GoSharing)
(e) GoSharing packages: € 19.95/75 min, € 49.95/200 min, € 99.95/425 min (€ 0.23/min)
(f) Package of € 12/month: unlimited number of trips of max. 40 minutes
(g) ConnectCar costs are lower during the night (2:00-7:00): € 0.91 (Smart), € 1.83 (Opel Zafira)
(h) Car2Go packages: € 17.90 (2h, 50 km), € 29.90 (4h, 70 km), € 79 (24 h, 90 km)
(i) Increasing costs for DonkeyRepublic: € 1.70 (<15min), € 2.20 (<30min), € 3.30 (<1h), € 5 (<2h), € 7.50 (<4h), € 9 (<6h), € 11 (<12h) etc.
(j) Additional costs of € 0.31/km if more than 200 km/trip or more than kms in package
(k) Additional costs of € 0.25/km if more than 50 km/h
(l) Additional costs of € 0.25/km if more than 250 km/trip or 250 km/day

Appendix A3: Overview costs mobility hubs

Table A2: Overview costs mobility hubs, information retrieved from (Beamrz, 2019; Hely, 2019; Huub, 2019)

	Hely	**Huub**			**Beamrz**	
Shared mode	Hub	Hub			Hub	
Registration fee	€ 0					
Subscription		A	B	C	A	B
€/month	€ 4.95 (a)	€ 0	€ 50	€ 200	€ 9.90	€ 14.9
Usage costs						
€/time	€ 0	€ 2	€ 0	€ 0	€ 0	€ 0
Vehicle type 1	E-bike *(Urbee)*	Bicycle			Car	
€/min	-				-	
€/hour	€ 1.50	€ 1	€ 1	€ 1	€ 3.95	
€/day	€ 9	€ 6	€ 4	€ 4	€ 35	
€/km	€ 0.00				€ 0.44	
€/km (100+ km)						
Vehicle type 2	C-bicycle *(Cargoroo)*	E-bike			Bicycle	
€/hour	€ 4	€ 2	€ 2	€ 1	€ 0.99	
€/day	€ 24	€ 12	€ 8	€ 4		
€/km	€ 0.00					
€/km (100+ km)						
Vehicle type 3	Citroën C1 *(MyWheels)*	E-moped				
€/hour	€ 7.50	€ 5	€ 5	€ 3		
€/day	€ 45	€ 30	€ 20	€ 12		
€/km	€ 0.00					
Vehicle type 4	Citroën C3, C4, Cactus / Nissan Leaf	E-cargo bicycle				
€/hour	€ 10.50	€ 5	€ 5	€ 3		
€/day	€ 63	€ 30	€ 20	€ 12		
€/km	€ 0.00					
Vehicle type 4		Compact car				
€/hour		€ 6	€ 6	€ 4		
€/day			€ 36	€ 24		
Vehicle type 5		Middle class car				
€/hour		€ 8	€ 8	€ 6		
€/day			€ 48	€ 36		
Vehicle type 6		Luxury car				
€/hour		€ 20	€ 20	€ 10		
€/day			€ 120	€ 60		
Vehicle type 7		Bus				
€/hour		€ 20	€ 20	€ 15		
€/day			€ 120	€ 90		
Vehicle type 8		Greenwheels				
€/hour		€ 9	€ 9	€ 9		
€/day			€ 88	€ 88		

Appendix A4: Overview yearly distance of first & non-first cars in the households

*Table A3: Distribution of average yearly distance of people in the Netherlands with their first car and non-first cars in the household, based on MPN-data of 2016 (KiM, 2016)**

Distance	**First car**		**Non-first cars**		**Total**	
	Percentage	*Cumulative*	*Percentage*	*Cumulative*	*Percentage*	*Cumulative*
<7.500 km	18.4%	18.4%	32.4%	32.4%	22.7%	22.7%
7.500-15.000 km	43.1%	61.5%	38.9%	71.3%	41.8%	64.5%
15.000-25.000 km	22.4%	83.9%	18.9%	90.2%	21.3%	85.9%
25.000-35.000 km	8.4%	92.3%	5.1%	95.3%	7.4%	93.2%
≥35.000 km	7.7%	100.0%	4.7%	100.0%	6.8%	100.0%
** Category "do not know/want to say" excluded*						

Appendix A5: Cost comparison of private car ownership and one-way carsharing

Note: The costs of Car2Go (€ 0.31/min) are approximately equal to the costs of Witkar and Fetch (both € 0.30/min). Therefore, only the costs of Car2Go have been depicted in Figure A2 to compare the costs in an organised manner.

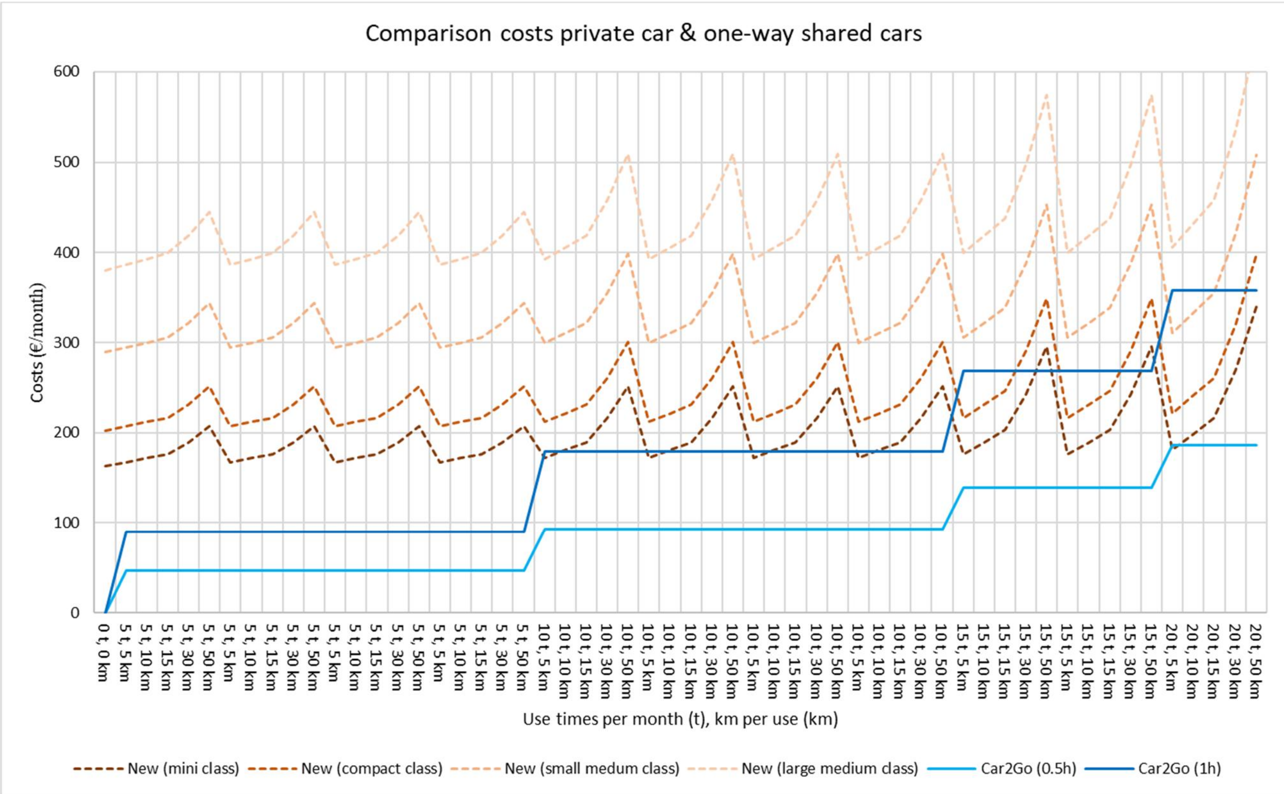

Figure A2: Comparison of the costs of private car ownership and free-floating shared cars

Appendix A6: Overview distribution travel time of commuting trips in the Netherlands

Table A4: Distribution of travel times of commuting trips for the Netherlands, very densely populated areas (UL1) and densely populated areas (UL=2) in the Netherlands, based on MPN-data of 2016 (KiM, 2016)

Travel time	**The Netherlands**		**Urbanity level = 1**		**Urbanity level = 2**	
	Percentage	*Cumulative*	*Percentage*	*Cumulative*	*Percentage*	*Cumulative*
1-5 minutes	0.5%	0.5%	0.2%	0.2%	0.4%	0.4%
5-10 minutes	6.3%	6.8%	2.7%	2.9%	5.9%	6.3%
10-15 minutes	10.8%	17.6%	8.6%	11.5%	10.9%	17.2%
15-20 minutes	14.6%	32.2%	12.5%	24.0%	14.6%	31.8%
20-25 minutes	12.6%	44.7%	13.4%	37.4%	13.1%	44.9%
25-30 minutes	9.8%	54.5%	8.8%	46.1%	9.5%	54.4%
30-45 minutes	25.0%	79.5%	26.1%	72.2%	25.0%	79.4%
45-60 minutes	9.8%	89.3%	14.8%	87.1%	10.5%	89.9%
60-90 minutes	8.0%	97.3%	9.2%	96.2%	8.2%	98.1%
90-120 minutes	1.7%	99.0%	1.9%	98.1%	1.2%	99.4%
120 minutes or more	1.0%	100.0%	1.9%	100.0%	0.6%	100.0%

Appendix A7: Distribution of Felyx mopeds on two days

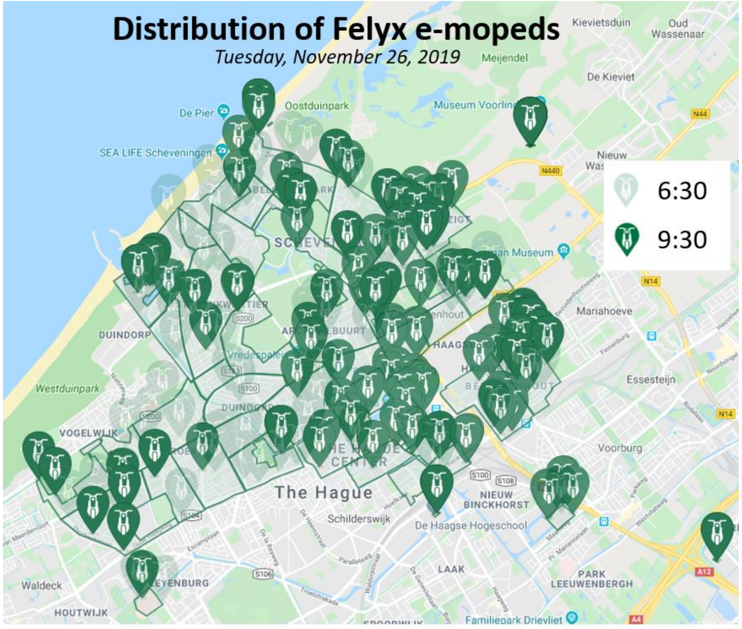

Figure A3: Distribution of Felyx e-mopeds before/after morning peak, adapted from Felyx (2019)

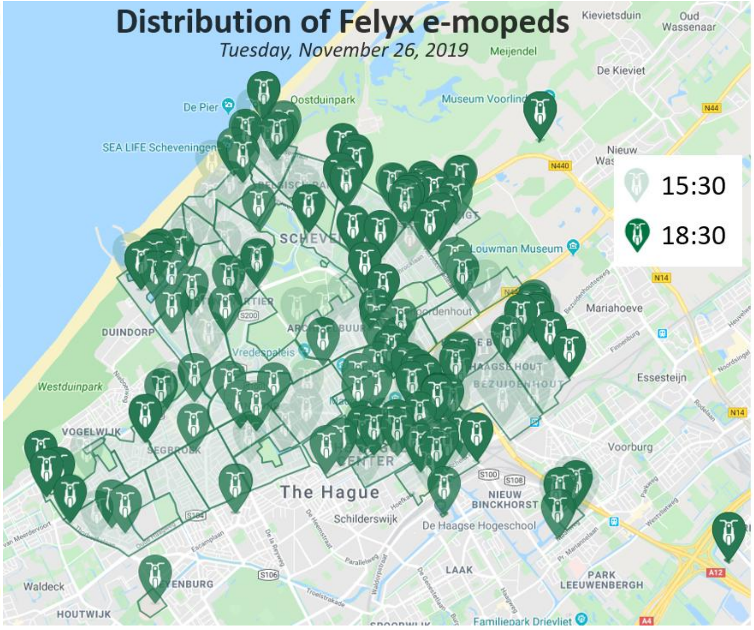

Figure A4: Distribution of Felyx e-mopeds before/after evening peak, adapted from Felyx (2019)

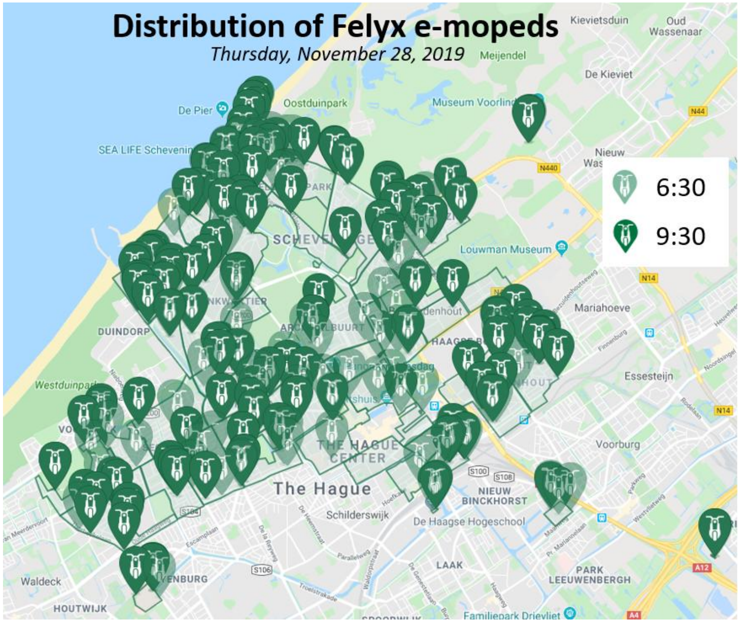

Figure A5: Distribution of Felyx e-mopeds before/after morning peak, adapted from Felyx (2019)

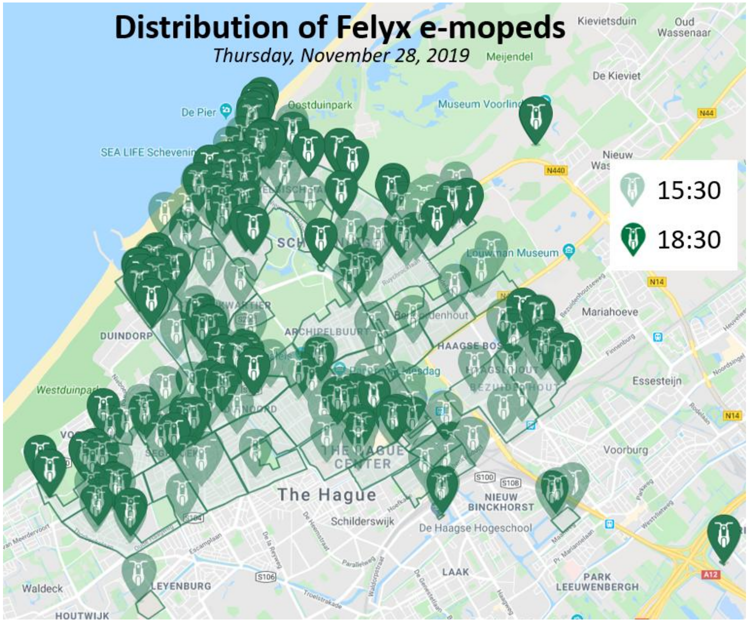

Figure A6: Distribution of Felyx e-mopeds before/after evening peak, adapted from Felyx (2019)

Appendix A8: Overview of inconvenience costs

Table A5: Overview of inconvenience costs of different suppliers of shared modes
(Buurauto, 2019; Car2Go, 2019; Cargoroo, 2019; ConnectCar, 2019; Donkey Republic, 2019; Felyx, 2019; Fetch, 2019; GoSharing, 2019; Greenwheels, 2019; HTM, 2019; JUMP, 2019; Mobike, 2019; MyWheels, 2019; NS, 2019; Witkar, 2019)

	Greenwheels	MyWheels	ConnectCar	Buurauto	Car2Go	Witkar	Fetch	Felyx	GoSharing	Cargoroo	JUMP	Donkey	Mobike	NS	HTM
Shared mode	Car	Car	Car	Car	Car	Car	Car	E-moped	E-moped	e-cargo bic.	e-bicycle	(e-)bicycle	Bicycle	Bicycle	Bicycle
System characteristics															
One way or round trip	Round-trip	Round-trip	Round-trip	Round-trip	One-way	One-way	One-way	One-way	One-way	Round-trip	One-way	One-way	One-way	Round-trip	One-way
Drop off zones	n/a	n/a	n/a	n/a	city	zones	city	city	city	n/a	city	zones	city	n/a	zones
Free parking	n/a	n/a	n/a	n/a	yes	yes	yes	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Deposit	€ 225 (c)	€ 0	€ 100	€ 0	€ 0	€ 100	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Own risk	€ 350	€ 500	€ 0	€ 300 (d)	€ 500	€ 0	€ 500	€ 500	€ 500	€ 50 - 100	€ 0	€ 180-600	€ 0	€ 50	€ 0
Costs for reducing risk	€ 4/trip	€ 3,50/trip	n/a	€10/month	n/a	n/a	-	-	-	-	n/a	€ 2/day	n/a	n/a	-
Reduced own risk	€ 75	€ 250	n/a	€ 100 (d)	n/a	n/a	-	-	-	-	n/a	€ 30-60	n/a	n/a	-
Min. rental time	15 min	15 min	1 hour	1 hour	1 min	1 min	1 min	1 min	1 min	1 min	1 min	15 min	20 min	1 day	30 min
Maximum users	1-3	1	1	household	1	1	1	1	1	family	1	5	1	2	4
Booking application															
Reservation option	+	+	+	+	+	-	+	+	+	+	+	-	+	-	+
Min. reservation time	-	-	1 hour	-	-	n/a	-	-	-	-	-	n/a	-	n/a	-
Max. reservation time	1 year	-	-	-	20 min	n/a	15 min (a)	15 min (b)	15 min	20 min	5 min	n/a	15 min	n/a	30 min
Users	Everybody	Everybody	Everybody	Neighbours	Everybody	Everybody	Everybody	Everybody	Everybody	Everybody	Everybody	Everybody	Everybody	Everybody	Everybody

(a) Costs for longer reservation time: €3 (0.5h), €4,50 (1h), €6 (2h), €12 (4h), €20 (8h), €32 (12h), €50 (1d), €100 (2d)
(b) Costs for longer reservation time: € 0.15/min
(c) Deposit can be charged as a reservation on a creditcard
(d) In case of age < 25 years, own risk is € 500, and € 300 when reducing own risk

Appendix B: Survey

Appendix B1: Explanation cost attributes

The costs levels of experiment 1 have been based on the costs of current suppliers and the costs of a private car. Since the costs of suppliers of shared mode depend on duration only or duration and distance, the costs have been expressed in costs per distance for different durations and distances. The costs of the suppliers vary between €0.31/km and €1.32/km. The costs for a private car (A or B segment) vary between €0.25/km and €0.73/km. Duncan (2011) noted that a key element for the potential growth of sharing is the ability to provide cost savings. In addition, it is expected that almost all people would not consider using the mobility hub when the costs are higher compared to their car. Therefore, the attribute levels vary between €0.20/km and €0.50/km.

Table B1: Costs calculation suppliers

Supplier	Duration (round)	Distance (round)	Total costs	Costs per km
Greenwheels *€ 0.24 / km* *€ 3 / hour*	4.5 h	25 km	€ 19.50	€ 0.78
	4.5 h	50 km	€ 25.50	€ 0.51
	4.5 h	75 km	€ 31.50	€ 0.42
	4.5 h	100 km	€ 37.50	€ 0.38
	9 h	25 km	€ 33.00	€ 1.32
	9 h	50 km	€ 39.00	€ 0.78
	9 h	75 km	€ 45.00	€ 0.60
	9 h	100 km	€ 51.00	€ 0.51
Buurauto *€ 0.5 / km* *€ 2 / hour*	4.5 h	25 km	€ 21.50	€ 0.86
	4.5 h	50 km	€ 34.00	€ 0.68
	4.5 h	75 km	€ 46.50	€ 0.62
	4.5 h	100 km	€ 59.00	€ 0.59
	9 h	25 km	€ 30.50	€ 1.22
	9 h	50 km	€ 43.00	€ 0.86
	9 h	75 km	€ 55.50	€ 0.74
	9 h	100 km	€ 68.00	€ 0.68
Buurauto *€ 0.3 / km* *€ 0.50 / hour*	4.5 h	25 km	€ 9.75	€ 0.39
	4.5 h	50 km	€ 17.25	€ 0.35
	4.5 h	75 km	€ 24.75	€ 0.33
	4.5 h	100 km	€ 32.25	€ 0.32
	9 h	25 km	€ 12.00	€ 0.48
	9 h	50 km	€ 19.50	€ 0.39
	9 h	75 km	€ 27.00	€ 0.36
	9 h	100 km	€ 34.50	€ 0.35
Supplier	**Duration (one-way)**	**Distance (one-way)**	**Total costs**	**Costs per km**
Car2Go *€ 0.31 / min* *Speed: 30 km/h*	10 min	5 km	€ 3.10	€ 0.62
	15 min	7.5 km	€ 4.65	€ 0.62
	20 min	10 km	€ 6.20	€ 0.62
	25 min	12.5 km	€ 7.75	€ 0.62
	30 min	15 km	€ 9.30	€ 0.62
Car2Go *€ 0.31 / min* *Speed: 45 km/h*	10 min	7.5 km	€ 3.10	€ 0.41
	15 min	11.3 km	€ 4.65	€ 0.41
	20 min	15 km	€ 6.20	€ 0.41
	25 min	18.8 km	€ 7.75	€ 0.41
	30 min	22.5 km	€ 9.30	€ 0.41
Car2Go *€ 0.31 / min* *Speed: 45 km/h*	10 min	10 km	€ 3.10	€ 0.31
	15 min	15 km	€ 4.65	€ 0.31
	20 min	20 km	€ 6.20	€ 0.31
	25 min	25 km	€ 7.75	€ 0.31
	30 min	30 km	€ 9.30	€ 0.31

Table B2: Costs calculation private car ownership

Private car	Distance per year	Costs per year	Costs per km
A-segment *€ 165/month* *€ 0.184/km*	5.000 km/year	€ 4,880	€ 0.58
	10.000 km/year	€ 5,800	€ 0.38
	15.000 km/year	€ 6,720	€ 0.32
	20.000 km/year	€ 7,640	€ 0.28
	25.000 km/year	€ 8,560	€ 0.26
	30.000 km/year	€ 9,480	€ 0.25
B-segment *€ 218/month* *€ 0.205/km*	5.000 km/year	€ 6,257	€ 0.73
	10.000 km/year	€ 7,282	€ 0.47
	15.000 km/year	€ 8,307	€ 0.38
	20.000 km/year	€ 9,332	€ 0.34
	25.000 km/year	€ 10,357	€ 0.31
	30.000 km/year	€ 11,382	€ 0.29

Appendix B2: Full factorial design

Table B3 shows the full factorial design of experiment 1. The full factorial design of experiment 2 is approximately equal to the full factorial design, with the addition of the attribute supply. In order to compose the full factorial design of experiment 2, this table should be doubled. The profiles in the original design have the attribute code of 1 for supply, whereas all profiles in the added table have an attribute code of -1 for supply.

Table B3: Full factorial design experiment 1

#	W1	W2	T1	T2	T3	RL1	R1	R2	U1
1	1	0	1	0	0	1	1	0	1
2	1	0	1	0	0	1	1	0	-1
3	1	0	1	0	0	1	0	1	1
4	1	0	1	0	0	1	0	1	-1
5	1	0	1	0	0	1	-1	-1	1
6	1	0	1	0	0	1	-1	-1	-1
7	1	0	1	0	0	-1	1	0	1
8	1	0	1	0	0	-1	1	0	-1
9	1	0	1	0	0	-1	0	1	1
10	1	0	1	0	0	-1	0	1	-1
11	1	0	1	0	0	-1	-1	-1	1
12	1	0	1	0	0	-1	-1	-1	-1
13	1	0	0	1	0	1	1	0	1
14	1	0	0	1	0	1	1	0	-1
15	1	0	0	1	0	1	0	1	1
16	1	0	0	1	0	1	0	1	-1
17	1	0	0	1	0	1	-1	-1	1
18	1	0	0	1	0	1	-1	-1	-1
19	1	0	0	1	0	-1	1	0	1
20	1	0	0	1	0	-1	1	0	-1
21	1	0	0	1	0	-1	0	1	1
22	1	0	0	1	0	-1	0	1	-1
23	1	0	0	1	0	-1	-1	-1	1
24	1	0	0	1	0	-1	-1	-1	-1
25	1	0	0	0	1	1	1	0	1
26	1	0	0	0	1	1	1	0	-1
27	1	0	0	0	1	1	0	1	1
28	1	0	0	0	1	1	0	1	-1
29	1	0	0	0	1	1	-1	-1	1
30	1	0	0	0	1	1	-1	-1	-1
31	1	0	0	0	1	-1	1	0	1
32	1	0	0	0	1	-1	1	0	-1
33	1	0	0	0	1	-1	0	1	1
34	1	0	0	0	1	-1	0	1	-1
35	1	0	0	0	1	-1	-1	-1	1
36	1	0	0	0	1	-1	-1	-1	-1
37	1	0	-1	-1	-1	1	1	0	1
38	1	0	-1	-1	-1	1	1	0	-1
39	1	0	-1	-1	-1	1	0	1	1
40	1	0	-1	-1	-1	1	0	1	-1
41	1	0	-1	-1	-1	1	-1	-1	1
42	1	0	-1	-1	-1	1	-1	-1	-1
43	1	0	-1	-1	-1	-1	1	0	1
44	1	0	-1	-1	-1	-1	1	0	-1
45	1	0	-1	-1	-1	-1	0	1	1
46	1	0	-1	-1	-1	-1	0	1	-1
47	1	0	-1	-1	-1	-1	-1	-1	1
48	1	0	-1	-1	-1	-1	-1	-1	-1
49	0	1	1	0	0	1	1	0	1
50	0	1	1	0	0	1	1	0	-1
51	0	1	1	0	0	1	0	1	1
52	0	1	1	0	0	1	0	1	-1
53	0	1	1	0	0	1	-1	-1	1
54	0	1	1	0	0	1	-1	-1	-1
55	0	1	1	0	0	-1	1	0	1
56	0	1	1	0	0	-1	1	0	-1
57	0	1	1	0	0	-1	0	1	1
58	0	1	1	0	0	-1	0	1	-1
59	0	1	1	0	0	-1	-1	-1	1
60	0	1	1	0	0	-1	-1	-1	-1
61	0	1	0	1	0	1	1	0	1
62	0	1	0	1	0	1	1	0	-1
63	0	1	0	1	0	1	0	1	1
64	0	1	0	1	0	1	0	1	-1
65	0	1	0	1	0	1	-1	-1	1
66	0	1	0	1	0	1	-1	-1	-1
67	0	1	0	1	0	-1	1	0	1
68	0	1	0	1	0	-1	1	0	-1
69	0	1	0	1	0	-1	0	1	1
70	0	1	0	1	0	-1	0	1	-1
71	0	1	0	1	0	-1	-1	-1	1
72	0	1	0	1	0	-1	-1	-1	-1
73	0	1	0	0	1	1	1	0	1
74	0	1	0	0	1	1	1	0	-1
75	0	1	0	0	1	1	0	1	1
76	0	1	0	0	1	1	0	1	-1
77	0	1	0	0	1	1	-1	-1	1
78	0	1	0	0	1	1	-1	-1	-1
79	0	1	0	0	1	-1	1	0	1
80	0	1	0	0	1	-1	1	0	-1
81	0	1	0	0	1	-1	0	1	1
82	0	1	0	0	1	-1	0	1	-1
83	0	1	0	0	1	-1	-1	-1	1
84	0	1	0	0	1	-1	-1	-1	-1
85	0	1	-1	-1	-1	1	1	0	1
86	0	1	-1	-1	-1	1	1	0	-1
87	0	1	-1	-1	-1	1	0	1	1
88	0	1	-1	-1	-1	1	0	1	-1
89	0	1	-1	-1	-1	1	-1	-1	1
90	0	1	-1	-1	-1	1	-1	-1	-1
91	0	1	-1	-1	-1	-1	1	0	1
92	0	1	-1	-1	-1	-1	1	0	-1
93	0	1	-1	-1	-1	-1	0	1	1
94	0	1	-1	-1	-1	-1	0	1	-1
95	0	1	-1	-1	-1	-1	-1	-1	1
96	0	1	-1	-1	-1	-1	-1	-1	-1
97	-1	-1	1	0	0	1	1	0	1
98	-1	-1	1	0	0	1	1	0	-1
99	-1	-1	1	0	0	1	0	1	1
100	-1	-1	1	0	0	1	0	1	-1
101	-1	-1	1	0	0	1	-1	-1	1
102	-1	-1	1	0	0	1	-1	-1	-1
103	-1	-1	1	0	0	-1	1	0	1
104	-1	-1	1	0	0	-1	1	0	-1
105	-1	-1	1	0	0	-1	0	1	1
106	-1	-1	1	0	0	-1	0	1	-1
107	-1	-1	1	0	0	-1	-1	-1	1
108	-1	-1	1	0	0	-1	-1	-1	-1
109	-1	-1	0	1	0	1	1	0	1
110	-1	-1	0	1	0	1	1	0	-1
111	-1	-1	0	1	0	1	0	1	1
112	-1	-1	0	1	0	1	0	1	-1
113	-1	-1	0	1	0	1	-1	-1	1
114	-1	-1	0	1	0	1	-1	-1	-1
115	-1	-1	0	1	0	-1	1	0	1
116	-1	-1	0	1	0	-1	1	0	-1
117	-1	-1	0	1	0	-1	0	1	1
118	-1	-1	0	1	0	-1	0	1	-1
119	-1	-1	0	1	0	-1	-1	-1	1
120	-1	-1	0	1	0	-1	-1	-1	-1
121	-1	-1	0	0	1	1	1	0	1
122	-1	-1	0	0	1	1	1	0	-1
123	-1	-1	0	0	1	1	0	1	1
124	-1	-1	0	0	1	1	0	1	-1
125	-1	-1	0	0	1	1	-1	-1	1
126	-1	-1	0	0	1	1	-1	-1	-1
127	-1	-1	0	0	1	-1	1	0	1
128	-1	-1	0	0	1	-1	1	0	-1
129	-1	-1	0	0	1	-1	0	1	1
130	-1	-1	0	0	1	-1	0	1	-1
131	-1	-1	0	0	1	-1	-1	-1	1
132	-1	-1	0	0	1	-1	-1	-1	-1
133	-1	-1	-1	-1	-1	1	1	0	1
134	-1	-1	-1	-1	-1	1	1	0	-1
135	-1	-1	-1	-1	-1	1	0	1	1
136	-1	-1	-1	-1	-1	1	0	1	-1
137	-1	-1	-1	-1	-1	1	-1	-1	1
138	-1	-1	-1	-1	-1	1	-1	-1	-1
139	-1	-1	-1	-1	-1	-1	1	0	1
140	-1	-1	-1	-1	-1	-1	1	0	-1
141	-1	-1	-1	-1	-1	-1	0	1	1
142	-1	-1	-1	-1	-1	-1	0	1	-1
143	-1	-1	-1	-1	-1	-1	-1	-1	1
144	-1	-1	-1	-1	-1	-1	-1	-1	-1

Appendix B3: Example of survey questions

Household car ownership: 1 car and no plans to buy/relinquish a car

Introduction

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Beste inwoner van Den Haag,

Universiteit Twente doet in samenwerking met Arcadis in uw wijk onderzoek naar deelvervoermiddelen (zoals deelauto's, deelscooters, elektrische deelfietsen en bakfietsen). Er is weinig bekend over de (toekomstige) behoefte aan deze vervoermiddelen. Door deelname aan de enquête helpt u ons hierin inzicht te krijgen. De resultaten van dit onderzoek worden gebruikt bij de verdere uitwerking van het beleid omtrent deelvervoermiddelen.

Uw hulp is hierbij zeer welkom. Door het invullen van de enquête maakt u kans op één van de 20 Bol.com cadeaubonnen van €25, €50 en €100. Het invullen van de enquête duurt maximaal 10 minuten. De gegevens zullen anoniem worden verwerkt. De enquête is met medewerking van de Gemeente Den Haag verspreid.

Hartelijk dank!

Volgende →

General information

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Wat is uw postcode? *(bijvoorbeeld: 2511AA)*

Hoeveel auto's zijn er in uw huishouden aanwezig?

- ◯ Geen auto's
- ◯ 1 auto
- ◯ 2 auto's
- ◯ 3 of meer auto's

Bent u of iemand anders in uw huishouden van plan om een <u>extra</u> auto te kopen of leasen binnen 1 jaar?

- ◯ Ja
- ◯ Nee

Volgende →

Car information

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De auto in mijn huishouden is...

- Door mij of iemand anders in mijn huishouden gekocht
- Door mij of iemand anders in mijn huishouden geleased *(private lease)*
- Een lease auto van het werk of bedrijfsauto
- Dat weet ik niet / wil ik niet zeggen

Hoeveel kilometer per jaar wordt er met de auto in uw huishouden gereden?

- 0 tot 5.000 km/jaar
- 5.000 tot 10.000 km/jaar
- 10.000 tot 15.000 km/jaar
- 15.000 tot 20.000 km/jaar
- 20.000 tot 25.000 km/jaar
- 25.000 km/jaar of meer

Van welke autoklasse is de auto in uw huishouden?

- Miniklasse *(bijvoorbeeld: Toyota Aygo, Peugeot 108, Kia Picanto)*
- Compacte klasse *(bijvoorbeeld: Volkswagen Polo, Ford Fiesta, Hyundai Kona)*
- Compacte middenklasse *(bijvoorbeeld: Ford Focus, Volkswagen Golf, Kia Niro)*
- Middenklasse *(bijvoorbeeld: Tesla model 3, Peugeot 508, BMW-3)*
- Andere autoklasse
- Dat weet ik niet

Bent u of iemand anders in uw huishouden van plan om een auto weg te doen binnen 1 jaar en deze niet te vervangen door een andere auto?

- Ja
- Misschien
- Nee

Volgende →

Frequency use modes

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Hoe vaak maakt u gebruik van onderstaande vervoermiddelen?

	4 of meer dagen per week	1 tot 3 dagen per week	1 tot 3 dagen per maand	6 tot 11 dagen per jaar	1 tot 5 dagen per jaar	Minder dan 1 dag per jaar	Nooit
Auto							
Trein							
Bus/tram/metro							
Fiets/e-bike							
Lopen							
Brommer/scooter							

Volgende →

Preferred transport mode

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Welk vervoermiddel heeft uw voorkeur als hoofdvervoermiddel als u...
Het gaat hier om welk vervoermiddel u het liefste gebruikt en niet om welke u het meest gebruikt.

Welk vervoermiddel heeft uw voorkeur als hoofdvervoermiddel als u **naar uw werk gaat**?

- ○ Niet van toepassing
- ○ Auto
- ○ Trein
- ○ Bus/tram/metro
- ○ Fiets/e-bike
- ○ Lopen
- ○ Brommer/scooter
- ○ Motor

Welk vervoermiddel heeft uw voorkeur als hoofdvervoermiddel als u **een zakelijke reis in werksfeer maakt**?

- ○ Niet van toepassing
- ○ Auto
- ○ Trein
- ○ Bus/tram/metro
- ○ Fiets/e-bike
- ○ Lopen
- ○ Brommer/scooter
- ○ Motor

Welk vervoermiddel heeft uw voorkeur als hoofdvervoermiddel als u **naar school/studie gaat**?

- ○ Niet van toepassing
- ○ Auto
- ○ Trein
- ○ Bus/tram/metro
- ○ Fiets/e-bike
- ○ Lopen
- ○ Brommer/scooter
- ○ Motor

Welk vervoermiddel heeft uw voorkeur als hoofdvervoermiddel als u **dagelijkse boodschappen doet**?

- ◯ Niet van toepassing
- ◯ Auto
- ◯ Trein
- ◯ Bus/tram/metro
- ◯ Fiets/e-bike
- ◯ Lopen
- ◯ Brommer/scooter
- ◯ Motor

Welk vervoermiddel heeft uw voorkeur als hoofdvervoermiddel als u **gaat winkelen**?

- ◯ Niet van toepassing
- ◯ Auto
- ◯ Trein
- ◯ Bus/tram/metro
- ◯ Fiets/e-bike
- ◯ Lopen
- ◯ Brommer/scooter
- ◯ Motor

Welk vervoermiddel heeft uw voorkeur als hoofdvervoermiddel als u **bij iemand op bezoek gaat**?

- ◯ Niet van toepassing
- ◯ Auto
- ◯ Trein
- ◯ Bus/tram/metro
- ◯ Fiets/e-bike
- ◯ Lopen
- ◯ Brommer/scooter
- ◯ Motor

Volgende →

Statements

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Geef van de volgende stellingen aan in hoeverre u het er mee eens bent.

	Zeer mee oneens	Enigszins mee oneens	Neutraal	Enigszins mee eens	Zeer mee eens
Mijn vrienden vinden dat je de auto alleen moet gebruiken als het echt nodig is.	○	○	○	○	○
Ik overweeg soms om de fiets en/of het OV te gebruiken in plaats van de auto.	○	○	○	○	○
Als anderen vaker voor milieuvriendelijke vervoermiddelen kiezen, dan zal ik dat ook doen.	○	○	○	○	○
Een auto zegt veel over iemands status in de samenleving.	○	○	○	○	○
Als deelauto's overal en op elk moment beschikbaar zijn, heb ik geen eigen auto nodig.	○	○	○	○	○
De auto geeft mij vrijheid.	○	○	○	○	○

Volgende →

Familiarity shared modes/mobility hub

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Kunt u deze vervoermiddelen binnen 500 meter *(6 minuten lopen)* vanaf uw woning bereiken?
Let op: huurauto's van autoverhuurbedrijven zijn geen deelauto's.

	Ja	Nee	Weet niet
Deelauto *(bijvoorbeeld: Greenwheels, Buurauto, MyWheels)*	○	○	○
Deelfiets *(bijvoorbeeld: OV-fiets, HTM-fiets, Mobike)*	○	○	○
Elektrische deelfiets	○	○	○
Deelbakfiets *(bijvoorbeeld: Cargoroo)*	○	○	○
Deelscooter *(bijvoorbeeld: Felyx)*	○	○	○

Hoe vaak gebruikt u één van deze deelvervoermiddelen?

- ○ 4 of meer dagen per week
- ○ 1 tot 3 dagen per week
- ○ 1 tot 3 dagen per maand
- ○ 6 tot 11 dagen per jaar
- ○ 1 tot 5 dagen per jaar
- ○ Minder dan 1 dag per jaar
- ○ Nooit

Heeft u wel eens over het concept van een mobiliteitshub gehoord?

- ○ Ja
- ○ Nee

Volgende →

Information about last (car)trip

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De volgende vragen gaan over uw laatste autoverplaatsing vanaf uw woning.

Waar ligt de bestemming van deze verplaatsing?

- ◯ In Den Haag
- ◯ Buiten Den Haag

Wat is de afstand van deze verplaatsing (enkele reis)?
(in hele kilometers)

[ ]

Wat is het reismotief van deze verplaatsing?

- ◯ Naar het werk
- ◯ Zakelijk bezoek in werksfeer
- ◯ Naar school/studie
- ◯ Ophalen/brengen personen/goederen
- ◯ Winkelen of boodschappen doen
- ◯ Visite
- ◯ Sport of hobby
- ◯ Anders, namelijk

[ ]

Hoe vaak maakt u deze verplaatsing?

- 4 of meer dagen per week
- 1 tot 3 dagen per week
- 1 tot 3 dagen per maand
- 6 tot 11 dagen per jaar
- 1 tot 5 dagen per jaar
- Minder dan 1 dag per jaar

Volgende →

Explanation stated choice experiment

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In de volgende vragen krijgt u steeds twee mogelijke autodeelsystemen te zien. U wordt gevraagd om uw voorkeur aan te geven als u uw laatste autoverplaatsing vanaf uw woning nog een keer zou maken. In totaal krijgt u 4 van deze situaties te zien.

De volgende vragen gaan dus over uw laatste autoverplaatsing vanaf uw woning.

De autodeelsystemen verschillen in de volgende kenmerken:

Looptijd	Het aantal minuten lopen naar de standplaats van de deelauto vanaf uw woning
Kosten	De kosten voor het gebruik van de deelauto
Inleverlocatie	De plaats waar u de deelauto inlevert: de standplaats waar u de deelauto heeft opgehaald of een locatie naar keuze
Reserveren	De tijd vooraf aan het gebruik dat u de deelauto moet reserveren
Gebruikers	De gebruikers van de deelauto: alleen bekenden of zowel bekenden als onbekenden

Volgende →

Choice set 1

Second question only in case of "Systeem A" OR "Systeem B".

Bekijk de volgende autodeelsystemen:

	Systeem A	Systeem B
Looptijd	9 minuten	3 minuten
Kosten	€ 0.30 / km	€ 0.50 / km
Inleverlocatie	Standplaats in uw wijk	Standplaats in uw wijk
Reserveren	Minstens 1 uur van tevoren	Niet nodig
Gebruikers	Bekenden en onbekenden	Bekenden en onbekenden

U maakt uw laatste autoverplaatsing vanaf uw woning nog een keer. U kunt gebruik maken van twee mogelijke autodeelsystemen. Welk systeem heeft dan uw voorkeur?

- ○ Systeem A
- ○ Systeem B
- ○ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ○ Eigen auto
- ○ Deelauto uit gekozen deelsysteem

Volgende →

Choice set 2

Second question only in case of “Systeem A” OR “Systeem B”.

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Bekijk de volgende autodeelsystemen:

	Systeem A	Systeem B
Looptijd	9 minuten	3 minuten
Kosten	€ 0.50 / km	€ 0.40 / km
Inleverlocatie	Locatie naar keuze	Standplaats in uw wijk
Reserveren	Niet nodig	Minstens 1 uur van tevoren
Gebruikers	Alleen bekenden	Alleen bekenden

U maakt uw laatste autoverplaatsing vanaf uw woning nog een keer. U kunt gebruik maken van twee mogelijke autodeelsystemen. Welk systeem heeft dan uw voorkeur?

- ○ Systeem A
- ○ Systeem B
- ○ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ○ Eigen auto
- ○ Deelauto uit gekozen deelsysteem

Volgende →

Choice set 3

Second question only in case of "Systeem A" OR "Systeem B".

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Bekijk de volgende autodeelsystemen:

	Systeem A	Systeem B
Looptijd	6 minuten	9 minuten
Kosten	€ 0.40 / km	€ 0.40 / km
Inleverlocatie	Locatie naar keuze	Locatie naar keuze
Reserveren	Minstens 30 min van tevoren	Niet nodig
Gebruikers	Bekenden en onbekenden	Alleen bekenden

U maakt uw laatste autoverplaatsing vanaf uw woning nog een keer. U kunt gebruik maken van twee mogelijke autodeelsystemen. Welk systeem heeft dan uw voorkeur?

- ○ Systeem A
- ○ Systeem B
- ○ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ○ Eigen auto
- ○ Deelauto uit gekozen deelsysteem

Volgende →

Choice set 4

Second question only in case of "Systeem A" OR "Systeem B".

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Bekijk de volgende autodeelsystemen:

	Systeem A	Systeem B
Looptijd	6 minuten	6 minuten
Kosten	€ 0.50 / km	€ 0.30 / km
Inleverlocatie	Locatie naar keuze	Standplaats in uw wijk
Reserveren	Minstens 1 uur van te voren	Niet nodig
Gebruikers	Bekenden en onbekenden	Alleen bekenden

U maakt uw laatste autoverplaatsing vanaf uw woning nog een keer. U kunt gebruik maken van twee mogelijke autodeelsystemen. Welk systeem heeft dan uw voorkeur?

- ○ Systeem A
- ○ Systeem B
- ○ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ○ Eigen auto
- ○ Deelauto uit gekozen deelsysteem

Volgende →

Information about last (car) trip from the respondent's dwelling to a destination in The Hague

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De volgende vragen gaan over uw laatste autoverplaatsing vanaf uw woning met een bestemming in Den Haag.

Wat is de afstand van deze verplaatsing (enkele reis)?
(in hele kilometers)

Wat is het reismotief van deze verplaatsing?

- ○ Naar het werk
- ○ Zakelijk bezoek in werksfeer
- ○ Naar school/studie
- ○ Ophalen/brengen personen/goederen
- ○ Winkelen of boodschappen doen
- ○ Visite
- ○ Sport of hobby
- ○ Anders, namelijk

Hoe vaak maakt u deze verplaatsing?

- ○ 4 of meer dagen per week
- ○ 1 tot 3 dagen per week
- ○ 1 tot 3 dagen per maand
- ○ 6 tot 11 dagen per jaar
- ○ 1 tot 5 dagen per jaar
- ○ Minder dan 1 dag per jaar

Volgende →

Explanation mobility hub

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Een **mobiliteitshub** is een locatie waar u auto's, scooters, elektrische fietsen (e-fietsen) en/of elektrische bakfietsen (e-bakfietsen) kunt huren.

- U kunt per rit kiezen welk vervoermiddel u wilt gebruiken
- Er is één mobiele applicatie voor reserveren, betalen en openen/sluiten van alle vervoermiddelen
- Er is geen wachttijd voor gebruik van de vervoermiddelen

In de volgende vragen krijgt u steeds twee mogelijke mobiliteitshubs te zien. U wordt gevraagd om uw voorkeur aan te geven als u uw laatste autoverplaatsing vanaf uw woning met een bestemming in Den Haag nog een keer zou maken. In totaal krijgt u 4 van deze situaties te zien.

De volgende vragen gaan dus over uw laatste autoverplaatsing vanaf uw woning met een bestemming in Den Haag.

De mobiliteitshubs verschillen in de volgende kenmerken:

Aanbod	De vervoermiddelen in de mobiliteitshub
Looptijd	Het aantal minuten lopen naar de mobiliteitshub vanaf uw woning
Kosten	De kosten voor het gebruik van de deelvervoermiddelen
Inleverlocatie	De plaats waar u het deelvervoermiddel inlevert: de mobiliteitshub waar u het deelvervoermiddel heeft opgehaald of een locatie naar keuze
Reserveren	De tijd vooraf aan het gebruik dat u het deelvervoermiddel moet reserveren
Gebruikers	De gebruikers van de deelvervoermiddelen: alleen bekenden of zowel bekenden als onbekenden

Volgende →

Choice set 1

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Bekijk de volgende mobiliteitshubs:

	Mobiliteitshub A	Mobiliteitshub B
Aanbod	Auto, scooter, e-fiets, e-bakfiets	Scooter, e-fiets, e-bakfiets
Looptijd	3 minuten	3 minuten
Kosten	Auto: € 0.40 / km Scooter: € 0.30 / km E-fiets: € 0.30 / km E-bakfiets: € 0.30 / km	Scooter: € 0.10 / km E-fiets: € 0.10 / km E-bakfiets: € 0.10 / km
Inleverlocatie	Mobiliteitshub in uw wijk	Locatie naar keuze
Reserveren	Minstens 30 min van tevoren	Niet nodig
Gebruikers	Alleen bekenden	Alleen bekenden

U maakt uw laatste autoverplaatsing vanaf uw woning met een bestemming in Den Haag nog een keer. U kunt gebruik maken van twee mogelijke mobiliteitshubs. Welke mobiliteitshub heeft dan uw voorkeur?

- ○ Mobiliteitshub A
- ○ Mobiliteitshub B
- ○ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ○ Eigen auto
- ○ Deelauto uit gekozen mobiliteitshub
- ○ Deelscooter uit gekozen mobiliteitshub
- ○ Elektrische deelfiets uit gekozen mobiliteitshub
- ○ Elektrische deelbakfiets uit gekozen mobiliteitshub

Volgende →

Choice set 2

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Bekijk de volgende mobiliteitshubs:

	Mobiliteitshub A	Mobiliteitshub B
Aanbod	Auto, scooter, e-fiets, e-bakfiets	Scooter, e-fiets, e-bakfiets
Looptijd	3 minuten	3 minuten
Kosten	Auto: € 0.40 / km Scooter: € 0.30 / km E-fiets: € 0.30 / km E-bakfiets: € 0.30 / km	Scooter: € 0.10 / km E-fiets: € 0.10 / km E-bakfiets: € 0.10 / km
Inleverlocatie	Locatie naar keuze	Mobiliteitshub in uw wijk
Reserveren	Niet nodig	Minstens 30 min van tevoren
Gebruikers	Bekenden en onbekenden	Bekenden en onbekenden

U maakt uw laatste autoverplaatsing vanaf uw woning met een bestemming in Den Haag nog een keer. U kunt gebruik maken van twee mogelijke mobiliteitshubs. Welke mobiliteitshub heeft dan uw voorkeur?

- ○ Mobiliteitshub A
- ○ Mobiliteitshub B
- ○ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ○ Eigen auto
- ○ Deelauto uit gekozen mobiliteitshub
- ○ Deelscooter uit gekozen mobiliteitshub
- ○ Elektrische deelfiets uit gekozen mobiliteitshub
- ○ Elektrische deelbakfiets uit gekozen mobiliteitshub

Volgende →

Choice set 3

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Bekijk de volgende mobiliteitshubs:

	Mobiliteitshub A	Mobiliteitshub B
Aanbod	Scooter, e-fiets, e-bakfiets	Scooter, e-fiets, e-bakfiets
Looptijd	3 minuten	6 minuten
Kosten	Scooter: € 0.20 / km E-fiets: € 0.20 / km E-bakfiets: € 0.20 / km	Scooter: € 0.40 / km E-fiets: € 0.40 / km E-bakfiets: € 0.40 / km
Inleverlocatie	Mobiliteitshub in uw wijk	Mobiliteitshub in uw wijk
Reserveren	Minstens 1 uur van tevoren	Niet nodig
Gebruikers	Bekenden en onbekenden	Alleen bekenden

U maakt uw laatste autoverplaatsing vanaf uw woning met een bestemming in Den Haag nog een keer. U kunt gebruik maken van twee mogelijke mobiliteitshubs. Welke mobiliteitshub heeft dan uw voorkeur?

- ○ Mobiliteitshub A
- ○ Mobiliteitshub B
- ○ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ○ Eigen auto
- ○ Deelauto uit gekozen mobiliteitshub
- ○ Deelscooter uit gekozen mobiliteitshub
- ○ Elektrische deelfiets uit gekozen mobiliteitshub
- ○ Elektrische deelbakfiets uit gekozen mobiliteitshub

Volgende →

Choice set 4

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Bekijk de volgende mobiliteitshubs:

	Mobiliteitshub A	Mobiliteitshub B
Aanbod	Auto, scooter, e-fiets, e-bakfiets	Auto, scooter, e-fiets, e-bakfiets
Looptijd	6 minuten	3 minuten
Kosten	Auto: € 0.40 / km Scooter: € 0.20 / km E-fiets: € 0.20 / km E-bakfiets: € 0.20 / km	Auto: € 0.40 / km Scooter: € 0.40 / km E-fiets: € 0.40 / km E-bakfiets: € 0.40 / km
Inleverlocatie	Locatie naar keuze	Mobiliteitshub in uw wijk
Reserveren	Minstens 30 min van tevoren	Minstens 1 uur van tevoren
Gebruikers	Alleen bekenden	Alleen bekenden

U maakt uw laatste autoverplaatsing vanaf uw woning met een bestemming in Den Haag nog een keer. U kunt gebruik maken van twee mogelijke mobiliteitshubs. Welke mobiliteitshub heeft dan uw voorkeur?

- ◯ Mobiliteitshub A
- ◯ Mobiliteitshub B
- ◯ Geen van beide

Welk vervoermiddel heeft uw voorkeur voor deze verplaatsing?

- ◯ Eigen auto
- ◯ Deelauto uit gekozen mobiliteitshub
- ◯ Deelscooter uit gekozen mobiliteitshub
- ◯ Elektrische deelfiets uit gekozen mobiliteitshub
- ◯ Elektrische deelbakfiets uit gekozen mobiliteitshub

Volgende →

Intention to reduce car ownership

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Hoe belangrijk is de beschikbaarheid van de volgende vervoermiddelen in een mobiliteitshub in de keuze om de auto weg te doen?

	Zeer onbelangrijk	Onbelangrijk	Neutraal	Belangrijk	Zeer belangrijk
Deelauto	○	○	○	○	○
Deelscooter	○	○	○	○	○
Elektrische deelfiets	○	○	○	○	○
Elektrische deelbakfiets	○	○	○	○	○

Hoe belangrijk zijn de volgende kenmerken van een mobiliteitshub in de keuze om de auto weg te doen?

	Zeer onbelangrijk	Onbelangrijk	Neutraal	Belangrijk	Zeer belangrijk
Looptijd naar de mobiliteitshub	○	○	○	○	○
Kosten	○	○	○	○	○
Inleveren op locatie naar keuze	○	○	○	○	○
Reserveringstijd	○	○	○	○	○
Delen met alleen bekenden	○	○	○	○	○

Als de mobiliteitshub naar uw voorkeur wordt aangeboden. Denkt u er dan over na om de auto weg te doen?

- ◯ Ja
- ◯ Misschien
- ◯ Nee

Volgende →

Information about socio demographic characteristics

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Wat is uw geslacht?

- ○ Man
- ○ Vrouw

Wat is uw leeftijd?

- ○ Jonger dan 20 jaar
- ○ 20 t/m 44 jaar
- ○ 45 t/m 64 jaar
- ○ 65 t/m 79 jaar
- ○ 80 jaar of ouder

Wat is uw hoogst voltooide opleiding?

- ○ Basisonderwijs, VMBO of MBO-1
- ○ MBO-2 t/m MBO-4, HAVO of VWO
- ○ HBO of WO

Wat is de samenstelling van uw huishouden?

- ○ Eenpersoonshuishouden
- ○ Samenwonend zonder kind(eren)
- ○ Samenwonend met kind(eren)
- ○ Eenoudergezin

Wat is het netto jaarinkomen van uw huishouden? *(besteedbaar inkomen)*

- ◯ < € 20.600
- ◯ € 20.600 tot € 29.600
- ◯ € 29.600 tot € 41.600
- ◯ € 41.600 tot € 58.200
- ◯ > € 58.200
- ◯ Weet niet / wil niet zeggen

Wat is uw werksituatie?

- ◯ Werkzaam in loondienst
- ◯ Zelfstandig ondernemer
- ◯ Werkloos, werkzoekende, bijstandsgerechtige of arbeidsongeschikt
- ◯ Student
- ◯ Vrijwilliger
- ◯ Gepensioneerd

Wilt u kans maken op één van de 20 Bol.com cadeaubonnen (t.w.v. €25, €50 en €100)? Vul dan uw e-mailadres in.

Versturen →

Appendix C: Descriptive statistics survey

Appendix C1: Relation between variables & frequency of shared mode use

*Table C1: Kendall's tau-b correlation matrix for car owners in sample A and sample B, * p ≤ 0.05, ** p ≤ 0.01*

		Frequency of shared mode use[a]	
		Sample A	**Sample B**
Gender[b]	Corr. coefficient	-0.040	-0.060
	Sig. (2-tailed)	0.330	0.140
	N	570	590
Age[c]	Corr. coefficient	-.236**	-.115**
	Sig. (2-tailed)	0.000	0.003
	N	570	590
Education[d]	Corr. coefficient	.099*	0.067
	Sig. (2-tailed)	0.014	0.093
	N	570	590
Household income[e]	Corr. coefficient	.133**	0.031
	Sig. (2-tailed)	0.002	0.470
	N	427	448
Number of cars[f]	Corr. coefficient	.106**	-0.034
	Sig. (2-tailed)	0.009	0.399
	N	570	590
Distance (least used) car[g]	Corr. coefficient	0.031	0.034
	Sig. (2-tailed)	0.395	0.352
	N	570	590
Frequency of car use[a]	Corr. coefficient	-0.033	-0.042
	Sig. (2-tailed)	0.388	0.284
	N	570	590
Frequency of train use[a]	Corr. coefficient	.180**	.183**
	Sig. (2-tailed)	0.000	0.000
	N	570	590
Frequency of BTM use[a]	Corr. coefficient	.092*	0.058
	Sig. (2-tailed)	0.012	0.105
	N	570	590
Frequency of (e-)bike use[a]	Corr. coefficient	0.057	0.055
	Sig. (2-tailed)	0.131	0.131
	N	570	590
Frequency of walking[a]	Corr. coefficient	-0.019	-0.013
	Sig. (2-tailed)	0.632	0.738
	N	570	590
Frequency of moped use[a]	Corr. coefficient	.390**	.089*
	Sig. (2-tailed)	0.000	0.025
	N	570	590

[a] 1= never, 2= <1day/year, 3= 1-5 days/year, 4= 6-11 days/year, 5= 1-3 days/month, 6= 1-3 days/week, 7= ≥4 days/week
[b] 1= men, 2= women
[c] 1= <20 years, 2= 20-45 years, 3= 45-65 years, 4= 65-80 years, 5= ≥80 years
[d] 1= low, 2= medium, 3= high
[e] 1= <€20,600, 2= €20,600-€29,600, 3= €29,600-41,600, 4= €41,600-€58,200, 5= ≥€58,200
[f] 1= 1 car/household, 2= >1 car/household
[g] 1= <5,000 km/year, 2= 5,000-10,000 km/year, 3= 10,000-15,000 km/year, 4= 15,000-20,000 km/year, 5= 20,000-25,000 km/year, 6= ≥25,000 km/year

Appendix C2: Relation car ownership & familiarity shared modes

Table C2: Household car ownership and familiarity with shared modes within 500 meters

		Sample A		Sample B	
Shared mode	**Within 500 meters?**	**1 car** (N=450)	**≥ 1 car** (N=120)	**1 car** (N=322)	**≥ 1 car** (N=268)
Shared car	Yes	229	57	27	20
	No	52	15	138	114
	Do not know	169	48	157	134
Shared bicycle	Yes	58	16	28	18
	No	132	38	168	142
	Do not know	260	66	126	108
Shared e-bicycle	Yes	22	4	3	4
	No	124	35	167	143
	Do not know	304	81	152	121
Shared e-cargo bicycle	Yes	89	25	1	3
	No	91	26	169	142
	Do not know	270	69	152	123
Shared moped	Yes	201	61	6	8
	No	48	8	157	140
	Do not know	201	51	159	120

Table C3: Household car ownership and familiarity with shared modes within 500 meters

		Sample A		Sample B	
Shared mode	**Within 500 meters?**	**1 car** (N=450)	**≥ 1 car** (N=120)	**1 car** (N=322)	**≥ 1 car** (N=268)
Shared car	Yes	50.9%	47.5%	8.4%	7.5%
	No	11.6%	12.5%	42.9%	42.5%
	Do not know	37.6%	40.0%	48.8%	50.0%
Shared bicycle	Yes	12.9%	13.3%	8.7%	6.7%
	No	29.3%	31.7%	52.2%	53.0%
	Do not know	57.8%	55.0%	39.1%	40.3%
Shared e-bicycle	Yes	4.9%	3.3%	0.9%	1.5%
	No	27.6%	29.2%	51.9%	53.4%
	Do not know	67.6%	67.5%	47.2%	45.1%
Shared e-cargo bicycle	Yes	19.8%	20.8%	0.3%	1.1%
	No	20.2%	21.7%	52.5%	53.0%
	Do not know	60.0%	57.5%	47.2%	45.9%
Shared moped	Yes	44.7%	50.8%	1.9%	3.0%
	No	10.7%	6.7%	48.8%	52.2%
	Do not know	44.7%	42.5%	49.4%	44.8%

Appendix C3: Relation frequency of shared mode use & familiarity shared modes

Table C4: Household car ownership and familiarity with shared modes within 500 meters, absolute numbers

		Sample A							Sample B						
Shared mode	**Within 500 meters?**	≥ 4 days/week	1-3 days/week	1-3 days/month	6-11 days/year	1-5 days/year	<1 day/year	Never	≥ 4 days/week	1-3 days/week	1-3 days/month	6-11 days/year	1-5 days/year	<1 day/year	Never
Shared car	Yes	1	4	28	11	17	6	225	2	1	1	1	1	2	39
	No	0	1	3	2	6	2	55	0	1	1	2	8	9	231
	Do not know	0	3	8	7	7	1	196	1	1	2	2	6	7	273
Shared bicycle	Yes	0	3	10	3	8	1	54	3	0	3	4	0	3	33
	No	0	4	18	9	10	5	127	0	3	1	1	12	12	281
	Do not know	1	1	11	8	12	3	295	0	0	0	0	3	3	229
Shared e-bicycle	Yes	0	0	4	2	3	0	19	1	1	1	1	0	0	3
	No	0	3	13	6	8	4	128	0	2	2	4	13	12	277
	Do not know	1	5	22	12	19	5	329	2	0	1	0	2	6	263
Shared e-cargo bicycle	Yes	1	5	18	5	10	1	76	0	0	1	0	0	0	3
	No	0	0	7	3	8	3	99	1	3	2	4	12	12	277
	Do not know	0	3	14	12	12	5	301	2	0	1	1	3	6	263
Shared moped	Yes	1	5	31	16	21	3	193	0	1	1	1	1	3	7
	No	0	0	2	1	3	1	50	1	2	2	4	10	11	267
	Do not know	0	3	6	3	6	5	233	2	0	1	0	4	4	269

Table C5: Household car ownership and familiarity with shared modes within 500 meters, percentages

		Sample A							Sample B						
Shared mode	**Within 500 meters?**	≥ 4 days/week	1-3 days/week	1-3 days/month	6-11 days/year	1-5 days/year	<1 day/year	Never	≥ 4 days/week	1-3 days/week	1-3 days/month	6-11 days/year	1-5 days/year	<1 day/year	Never
Shared car	Yes	100%	50%	72%	55%	57%	67%	47%	67%	33%	25%	20%	7%	11%	7%
	No	0%	13%	8%	10%	20%	22%	12%	0%	33%	25%	40%	53%	50%	43%
	Do not know	0%	38%	21%	35%	23%	11%	41%	33%	33%	50%	40%	40%	39%	50%
Shared bicycle	**Yes**	0%	38%	26%	15%	27%	11%	11%	100%	0%	75%	80%	0%	17%	6%
	No	0%	50%	46%	45%	33%	56%	27%	0%	100%	25%	20%	80%	67%	52%
	Do not know	100%	13%	28%	40%	40%	33%	62%	0%	0%	0%	0%	20%	17%	42%
Shared e-bicycle	Yes	0%	0%	10%	10%	10%	0%	4%	33%	33%	25%	20%	0%	0%	1%
	No	0%	38%	33%	30%	27%	44%	27%	0%	67%	50%	80%	87%	67%	51%
	Do not know	100%	63%	56%	60%	63%	56%	69%	67%	0%	25%	0%	13%	33%	48%
Shared e-cargo bicycle	Yes	100%	63%	46%	25%	33%	11%	16%	0%	0%	25%	0%	0%	0%	1%
	No	0%	0%	18%	15%	27%	33%	21%	33%	100%	50%	80%	80%	67%	51%
	Do not know	0%	38%	36%	60%	40%	56%	63%	67%	0%	25%	20%	20%	33%	48%
Shared moped	Yes	100%	63%	79%	80%	70%	33%	41%	0%	33%	25%	20%	7%	17%	1%
	No	0%	0%	5%	5%	10%	11%	11%	33%	67%	50%	80%	67%	61%	49%
	Do not know	0%	38%	15%	15%	20%	56%	49%	67%	0%	25%	0%	27%	22%	50%

Appendix C4: Relation shared mode use & familiarity shared modes

Table C6: Shared mode use & familiarity with shared modes in the proximity of the respondent's dwelling (<500m), absolute numbers

	Sample A			Sample B		
Use of specific shared mode	**Yes**	**No**	**Do not know**	**Yes**	**No**	**Do not know**
Shared car	20	1	2	3	4	1
Shared bicycle	5	8	5	5	17	4
Shared e-bicycle	2	0	1	2	1	1
Shared e-cargo bicycle	17	0	0	0	0	0
Shared moped	58	3	1	3	9	0

Table C7: Shared mode use & familiarity with shared modes in the proximity of the respondent's dwelling (<500m), percentages

	Sample A			Sample B		
Use of specific shared mode	**Yes**	**No**	**Do not know**	**Yes**	**No**	**Do not know**
Shared car	87.0%	4.3%	8.7%	37.5%	50.0%	12.5%
Shared bicycle	27.8%	44.4%	27.8%	19.2%	65.4%	15.4%
Shared e-bicycle	66.7%	0.0%	33.3%	50.0%	25.0%	25.0%
Shared e-cargo bicycle	100.0%	0.0%	0.0%	N/A	N/A	N/A
Shared moped	93.5%	4.8%	1.6%	25.0%	75.0%	0.0%

Appendix C5: Relation statements, gender & age

*Table C8: Kendall's tau-b correlation matrix for car owners in sample A (N=570), * p ≤ 0.05, ** p ≤ 0.01*

Statement		S1: Freedom car	S2: Use of bicycle /PT	S3: Shared cars available	S4: Status symbol	S5: Use of other people	S6: Friends about car use	Gender[a]	Age[b]
S1: The car gives me freedom	Corr. coefficient	1	-,122**	-,172**	0,067	-,118**	-,098**	,104**	-0,026
	Sig. (2-tailed)		0,001	0,000	0,067	0,001	0,007	0,009	0,483
	N		570	570	570	570	570	570	570
S2: I sometimes consider using the bicycle and/or PT instead of the car	Corr. coefficient		1	,132**	-,081*	,153**	,138**	0,015	0,035
	Sig. (2-tailed)			0,000	0,024	0,000	0,000	0,708	0,335
	N			570	570	570	570	570	570
S3: If shared cars would be available anywhere at any time, I do not need my car	Corr. coefficient			1	-0,067	,235**	,162**	0,036	-0,034
	Sig. (2-tailed)				0,053	0,000	0,000	0,334	0,328
	N				570	570	570	570	570
S4: A car says a lot about someone's social status	Corr. coefficient				1	,084*	-0,043	-,144**	0,056
	Sig. (2-tailed)					0,016	0,214	0,000	0,121
	N					570	570	570	570
S5: If other people would choose more often for sustainable modes, I would do that as well.	Corr. coefficient					1	,200**	0,006	-0,059
	Sig. (2-tailed)						0,000	0,867	0,095
	N						570	570	570
S6: My friends think you should only use the car if needed	Corr. coefficient						1	0,052	,095**
	Sig. (2-tailed)							0,171	0,008
	N							570	570

[a] 1=male, 2=female
[b] 1= <20years, 2= 20-45 years, 3= 45-65 years, 4= 65-80 years, 5= ≥80 years

*Table C9: Kendall's tau-b correlation matrix for car owners in sample B (N=590), * p ≤ 0.05, ** p ≤ 0.01*

Statement		S1: Freedom car	S2: Use of bicycle /PT	S3: Shared cars available	S4: Status symbol	S5: Use of other people	S6: Friends about car use	Gender[a]	Age[b]
S1: The car gives me freedom	Corr. coefficient	1	-,080*	-,081*	0,054	-0,050	-,079*	,095*	0,005
	Sig. (2-tailed)		0,029	0,024	0,137	0,169	0,029	0,017	0,884
	N		590	590	590	590	590	590	590
S2: I sometimes consider using the bicycle and/or PT instead of the car	Corr. coefficient		1	,180**	-0,011	,154**	,155**	0,013	-0,025
	Sig. (2-tailed)			0,000	0,761	0,000	0,000	0,732	0,479
	N			590	590	590	590	590	590
S3: If shared cars would be available anywhere at any time, I do not need my car	Corr. coefficient			1	0,021	,212**	,155**	0,055	-0,055
	Sig. (2-tailed)				0,538	0,000	0,000	0,135	0,115
	N				590	590	590	590	590
S4: A car says a lot about someone's social status	Corr. coefficient				1	0,060	-0,004	-,136**	0,043
	Sig. (2-tailed)					0,080	0,903	0,000	0,222
	N					590	590	590	590
S5: If other people would choose more often for sustainable modes, I would do that as well.	Corr. coefficient					1	,198**	,099**	-,079*
	Sig. (2-tailed)						0,000	0,008	0,026
	N						590	590	590
S6: My friends think you should only use the car if needed	Corr. coefficient						1	0,055	0,012
	Sig. (2-tailed)							0,142	0,745
	N							590	590

[a] 1=male, 2=female
[b] 1= <20years, 2= 20-45 years, 3= 45-65 years, 4= 65-80 years, 5= ≥80 years

Appendix C6: Relation statements, gender, age & frequency of mode use

*Table C10: Kendall's tau-b correlation matrix for car owners in sample A (N=570), * p ≤ 0.05, ** p ≤ 0.01*

Statement		Gender[a]	Age[b]	Car	Train	BTM	Bicycle	Walking	Moped
S1: The car gives me freedom	Corr. coefficient	.104**	-0.026	.224**	-.178**	-.078*	-.139**	-0.041	-0.044
	Sig. (2-tailed)	0.009	0.483	0	0	0.03	0	0.293	0.266
	N	570	570	570	570	570	570	570	570
S2: I sometimes consider using the bicycle and/or PT instead of the car	Corr. coefficient	0.015	0.035	-.260**	.182**	.127**	.281**	0.057	-0.03
	Sig. (2-tailed)	0.708	0.335	0	0	0	0	0.132	0.422
	N	570	570	570	570	570	570	570	570
S3: If shared cars would be available anywhere at any time, I do not need my car	Corr. coefficient	0.036	-0.034	-.221**	.179**	.113**	.139**	0.035	-0.042
	Sig. (2-tailed)	0.334	0.328	0	0	0.001	0	0.333	0.256
	N	570	570	570	570	570	570	570	570
S4: A car says a lot about someone's social status	Corr. coefficient	-.144**	0.056	.108**	-0.036	-0.001	-.079*	-.093*	0.001
	Sig. (2-tailed)	0	0.121	0.003	0.29	0.982	0.027	0.012	0.97
	N	570	570	570	570	570	570	570	570
S5: If other people would choose more often for sustainable modes, I would do that as well.	Corr. coefficient	0.006	-0.059	-0.047	.138**	.076*	.107**	-0.053	0.026
	Sig. (2-tailed)	0.867	0.095	0.191	0	0.026	0.002	0.15	0.492
	N	570	570	570	570	570	570	570	570
S6: My friends think you should only use the car if needed	Corr. coefficient	0.052	.095**	-.156**	.074*	0.002	.157**	0.014	-0.048
	Sig. (2-tailed)	0.171	0.008	0	0.028	0.954	0	0.7	0.2
	N	570	570	570	570	570	570	570	570

[a] 1=male, 2=female
[b] 1= <20years, 2= 20-45 years, 3= 45-65 years, 4= 65-80 years, 5= ≥80 years

*Table C11: Kendall's tau-b correlation matrix for car owners in sample B (N=590), * p ≤ 0.05, ** p ≤ 0.01*

Statement		Gender[a]	Age[b]	Car	Train	BTM	Bicycle	Walking	Moped
S1: The car gives me freedom	Corr. coefficient	.095*	0.005	.119**	-.113**	-0.063	-.098**	-.085*	-0.022
	Sig. (2-tailed)	0.017	0.884	0.002	0.001	0.072	0.007	0.021	0.567
	N	590	590	590	590	590	590	590	590
S2: I sometimes consider using the bicycle and/or PT instead of the car	Corr. coefficient	0.013	-0.025	-.212**	.213**	.242**	.263**	.122**	-0.023
	Sig. (2-tailed)	0.732	0.479	0.000	0.000	0.000	0.000	0.001	0.535
	N	590	590	590	590	590	590	590	590
S3: If shared cars would be available anywhere at any time, I do not need my car	Corr. coefficient	0.055	-0.055	-.197**	.126**	.099**	.110**	0.003	0.002
	Sig. (2-tailed)	0.135	0.115	0.000	0.000	0.003	0.001	0.925	0.965
	N	590	590	590	590	590	590	590	590
S4: A car says a lot about someone's social status	Corr. coefficient	-.136**	0.043	0.048	-0.041	-0.051	-0.032	0.00	0.04
	Sig. (2-tailed)	0	0.222	0.19	0.214	0.128	0.35	0.994	0.274
	N	590	590	590	590	590	590	590	590
S5: If other people would choose more often for sustainable modes, I would do that as well.	Corr. coefficient	.099**	-.079*	-0.066	.127**	.091**	.082*	0.024	-0.037
	Sig. (2-tailed)	0.008	0.026	0.073	0.000	0.006	0.015	0.487	0.313
	N	590	590	590	590	590	590	590	590
S6: My friends think you should only use the car if needed	Corr. coefficient	0.055	0.012	-.099**	.067*	0.064	.081*	0.025	-0.002
	Sig. (2-tailed)	0.142	0.745	0.007	0.046	0.055	0.017	0.477	0.959
	N	590	590	590	590	590	590	590	590

[a] 1=male, 2=female
[b] 1= <20years, 2= 20-45 years, 3= 45-65 years, 4= 65-80 years, 5= ≥80 years

Appendix D: Extended survey results

Appendix D1: Preferred carsharing systems (with attitudes/social norm)

Table D1: Estimation results MNL and ML model, preferred carsharing systems

Model	MNL				ML – Error components			
	Sample A		Sample B		Sample A		Sample B	
# draws	N/A		N/A		1000		1000	
# est. parameters	15		15		12		12	
# observations	2200		2240		2200		2240	
# individuals	550		560		550		560	
Final log LL	-2071.659		-2170.578		-1660.846		-1717.006	
Rho square	0.143		0.118		0.313		0.302	
Adj. rho square	0.137		0.112		0.308		0.297	
Parameter	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
ASC_{system}	0.725	0.00	0.053	0.76	2.35	0.00	1.07	0.14
$\beta_{travel\ costs}$	-0.407	0.00	-0.325	0.00	-0.620	0.00	-0.508	0.00
$\beta_{walking\ time}$	-0.369	0.00	-0.394	0.00	-0.602	0.00	-0.604	0.00
$\beta_{reservation}$	-0.582	0.00	-0.276	0.00	-0.799	0.00	-0.436	0.00
$\beta_{known\ users}$	0.189	0.00	0.322	0.00	0.244	0.00	0.357	0.00
$\beta_{no\ return\ needed}$	-0.160	0.02	-0.341	0.00			-0.254	0.00
$\beta_{pickup,dropoff}$			0.366	0.00				
$\beta_{45-65\ years}$	-0.744	0.00	-0.491	0.00	-1.93	0.01	-1.51	0.02
$\beta_{\geq 65\ years}$	-1.39	0.00	-1.18	0.00	-3.89	0.00	-3.92	0.00
$\beta_{high\ income}$	0.518	0.00	0.366	0.00	1.17	0.03		
$\beta_{one-person}$	0.479	0.00	0.560	0.00				
$\beta_{one-parent}$	1.60	0.00			3.18	0.02		
$\beta_{statement2}$			0.644	0.00			2.13	0.00
$\beta_{statement3}$	1.38	0.00	1.12	0.00	4.32	0.00	3.22	0.00
$\beta_{statement4}$	0.335	0.01	0.351	0.01	1.48	0.04		
$\beta_{statement5}$	0.344	0.01	0.566	0.00			1.68	0.01
$\beta_{statement6}$	0.306	0.02						
ζ_{system}					-5.04	0.00	-5.29	0.00

Appendix D2: Preferred carsharing systems (without attitudes/social norm)

Table D2: Estimation results MNL and ML model (without attitudes/social norm), preferred carsharing systems

Model	MNL				ML – Error components			
	Sample A		Sample B		Sample A		Sample B	
# draws	N/A		N/A		1000		1000	
# est. parameters	14		13		10		9	
# observations	2200		2240		2200		2240	
# individuals	550		560		550		560	
Final log LL	-2176.803		-2279.874		-1694.484		-1747.732	
Rho square	0.099		0.074		0.299		0.290	
Adj. rho square	0.094		0.068		0.295		0.286	
Parameter	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
ASC_{system}	1.20	0.00	0.893	0.00	4.76	0.00	4.63	0.00
$\beta_{travel\ costs}$	-0.384	0.00	-0.308	0.00	-0.621	0.00	-0.508	0.00
$\beta_{walking\ time}$	-0.338	0.00	-0.371	0.00	-0.602	0.00	-0.604	0.00
$\beta_{reservation}$	-0.545	0.00	-0.271	0.00	-0.798	0.00	-0.437	0.00
$\beta_{known\ users}$	0.187	0.00	0.320	0.00	0.244	0.00	0.358	0.00
$\beta_{no\ return\ needed}$	-0.193	0.00	-0.342	0.00			-0.253	0.00
$\beta_{>20\ km}$	-0.301	0.00						
$\beta_{visiting}$	0.317	0.01	0.347	0.02				
$\beta_{pickup,dropoff}$			-0.390	0.01				
$\beta_{<4\ days/week}$	0.424	0.00	0.240	0.03				
$\beta_{45-65\ years}$	-0.692	0.00	-0.424	0.00	-1.82	0.02	-1.51	0.03
$\beta_{\geq 65\ years}$	-1.49	0.00	-1.37	0.00	-4.17	0.00	-4.68	0.00
$\beta_{high\ income}$	0.660	0.00	0.314	0.00	1.59	0.01		
$\beta_{oneperson}$	0.424	0.00	0.509	0.01				
$\beta_{oneparent}$	1.47	0.00			3.60	0.01		
ζ_{system}					-5.57	0.00	-5.81	0.00

Table D3: MNL model with only system characteristics without alternative "None"

Model	MNL without "None"			
	Sample A		Sample B	
# est. parameters	5		5	
# observations	1485		1474	
# individuals				
Final log LL	-883.083		-882.394	
Rho square	0.142		0.136	
Adj. rho square	0.137		0.131	
Parameter	**Value**	**p-value**	**Value**	**p-value**
$\beta_{travel\ costs}$	-0.580	0.00	-0.517	0.00
$\beta_{walking\ time}$	-0.554	0.00	-0.611	0.00
$\beta_{reservation}$	-0.752	0.00	-0.443	0.00
$\beta_{known\ users}$	0.220	0.00	0.370	0.00
$\beta_{no\ return\ needed}$	-0.118	0.19	-0.227	0.01

Appendix D3: Preferred mobility hubs (with attitudes/social norm)

Table D4: Estimation results MNL and ML model, preferred mobility hubs

Model	MNL				ML – Error components			
	Sample A		Sample B		Sample A		Sample B	
# draws	N/A		N/A		1000		1000	
# est. parameters	15		13		12		14	
# observations	2280		2360		2280		2360	
# individuals	570		590		570		590	
Final log LL	-2149.614		-2304.048		-1767.053		-1824.139	
Rho square	0.142		0.111		0.295		0.296	
Adj. rho square	0.136		0.106		0.290		0.291	
Parameter	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
ASC_{hub}	-0.582	0.00	-1.24	0.00	0.521	0.35	-1.77	0.01
$\beta_{shared\ car}$	0.781	0.00	0.622	0.00	1.23	0.00	1.05	0.00
$\beta_{travel\ costs\ OM}$	0.319	0.00	0.240	0.00	0.510	0.00	0.451	0.00
$\beta_{walking\ time}$	-0.443	0.00	-0.376	0.00	-0.828	0.00	-0.790	0.00
$\beta_{reservation}$	-0.442	0.00	-0.383	0.00	-0.568	0.00	-0.534	0.00
$\beta_{known\ users}$					0.322	0.00	0.264	0.00
$\beta_{1-4\ d/month}$			0.247	0.01				
$\beta_{work/business}$			0.677	0.00			1.81	0.00
$\beta_{shopping}$	-0.248	0.02						
$\beta_{45-65\ years}$	-0.841	0.00	-0.565	0.00	-2.13	0.00	-1.77	0.00
$\beta_{\geq 65\ years}$	-1.26	0.00	-1.19	0.00	-3.43	0.00	-3.73	0.00
$\beta_{high\ income}$	0.250	0.01						
$\beta_{t\ without\ children}$	-0.632	0.00			-1.61	0.00		
$\beta_{single\ parent}$	0.602	0.01						
$\beta_{statement1}$								
$\beta_{statement2}$	0.261	0.02	0.371	0.00			1.13	0.04
$\beta_{statement3}$	0.907	0.00	0.847	0.00	2.56	0.00	2.48	0.00
$\beta_{statement4}$			0.396	0.00			1.31	0.02
$\beta_{statement5}$	0.635	0.00	0.594	0.00	1.78	0.00	1.85	0.00
$\beta_{statement6}$	0.254	0.03						
ζ_{system}					-4.20	0.00	4.67	0.00

Appendix D4: Preferred mobility hubs (without attitudes/social norm)

Table D5: Estimation results MNL and ML model (without attitudes/social norm), preferred mobility hubs

Model	MNL				ML – Error components			
	Sample A		Sample B		Sample A		Sample B	
# draws	N/A		N/A		1000		1000	
# est. parameters	12		10		11		10	
# observations	2280		2360		2280		2360	
# individuals	570		590		570		590	
Final log LL	-2234.408		-2384.835		-1793.224		-1852.629	
Rho square	0.108		0.080		0.284		0.285	
Adj. rho square	0.103		0.076		0.280		0.282	
Parameter	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
ASC_{hub}	0.273	0.06	-0.573	0.00	1.95	0.00	1.05	0.04
$\beta_{shared\ car}$	0.773	0.00	0.615	0.00	1.23	0.00	1.06	0.00
$\beta_{travel\ costs\ OM}$	0.315	0.00	0.233	0.00	0.511	0.00	0.453	0.00
$\beta_{walking\ time}$	-0.430	0.00	-0.364	0.00	-0.828	0.00	-0.794	0.00
$\beta_{reservation}$	-0.440	0.00	-0.374	0.00	-0.571	0.00	-0.535	0.00
$\beta_{known\ users}$					0.320	0.00	0.267	0.00
$\beta_{>5\ km}$	-0.247	0.01						
$\beta_{1-4\ d/month}$			0.318	0.00				
$\beta_{work/business}$			0.571	0.00			1.47	0.01
$\beta_{shopping}$	-0.221	0.04						
$\beta_{45-65\ years}$	-0.764	0.00	-0.506	0.00	-2.10	0.00	-1.74	0.00
$\beta_{\geq 65\ years}$	-1.22	0.00	-1.19	0.00	-3.58	0.00	-4.40	0.00
$\beta_{high\ income}$	0.373	0.00			1.01	0.03		
$\beta_{t\ with\ children}$			0.217	0.03				
$\beta_{t\ without\ children}$	-0.566	0.00			-1.71	0.00		
$\beta_{single\ parent}$	0.545	0.01						
ζ_{system}					-4.50	0.00	5.00	0.00

Table D6: MNL model with only hub characteristics without alternative "None"

Model	MNL without "None"			
	Sample A		Sample B	
# est. parameters	6		6	
# observations	1354		1362	
# individuals				
Final log LL	-838.943		-856.124	
Rho square	0.106		0.093	
Adj. rho square	0.100		0.087	
Parameter	**Value**	**p-value**	**Value**	**p-value**
$\beta_{shared\ car}$	0.875	0.00	0.765	0.00
$\beta_{travel\ costs\ OM}$	0.402	0.00	0.365	0.00
$\beta_{walking\ time}$	-0.532	0.00	-0.552	0.00
$\beta_{reservation}$	-0.583	0.00	-0.546	0.00
$\beta_{known\ users}$	0.002	0.99	-0.024	0.86
$\beta_{no\ return\ needed}$	-0.063	0.39	-0.023	0.75

Appendix D5: Intention to use the carsharing system (with attitudes/social norm)

Table D7: Estimation results MNL and ML model, intention to use the carsharing system

Model	MNL				ML – Error components			
	Sample A		Sample B		Sample A		Sample B	
# draws	N/A		N/A		1000		1000	
# est. parameters	9		11		8		7	
# observations	1485		1474		1485		1474	
# individuals	426		423		426		423	
Final log LL	-820.416		-841.269		-539.825		-560.913	
Rho square	0.203		0.177		0.476		0.451	
Adj. rho square	0.194		0.166		0.468		0.444	
Parameter	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
$ASC_{shared\ car}$	-0.325	0.16	-1.74	0.00	-1.52	0.21	-5.59	0.00
$\beta_{travel\ costs}$	-0.205	0.00	-0.253	0.00	-0.800	0.00	-0.821	0.00
$\beta_{walking\ time}$			-0.256	0.00	-0.500	0.00	-0.724	0.00
$\beta_{>20\ km}$	-0.474	0.00						
$\beta_{>40\ km}$			-0.619	0.00				
$\beta_{shopping}$	-0.827	0.00			-2.50	0.02		
$\beta_{visiting}$	0.395	0.01	0.866	0.00			1.98	0.03
β_{women}			-0.382	0.00				
$\beta_{\geq 45\ years}$			0.358	0.01				
$\beta_{t\ with\ children}$			0.405	0.00				
$\beta_{statement1}$	-1.35	0.00			-4.45	0.00		
$\beta_{statement2}$			0.516	0.00			1.99	0.04
$\beta_{statement3}$	-1.58	0.00	1.15	0.00	5.74	0.00	4.09	0.00
$\beta_{statement4}$	0.359	0.01						
$\beta_{statement5}$	0.473	0.00			1.75	0.02		
$\beta_{statement6}$			0.358	0.01				
$\zeta_{shared\ car}$					-5.68	0.00	5.77	0.00

Appendix D6: Intention to use the carsharing system (without attitudes/social norm)

Table D8: Estimation results MNL and ML model (without attitudes/social norm), intention to use the carsharing system

Model	MNL				ML – Error components			
	Sample A		Sample B		Sample A		Sample B	
# draws	N/A		N/A		1000		1000	
# est. parameters	7		8		7		7	
# observations	1485		1474		1485		1474	
# individuals	426		423		426		423	
Final log LL	-922.801		-902.070		-575.936		-577.894	
Rho square	0.103		0.117		0.440		0.434	
Adj. rho square	0.097		0.109		0.434		0.428	
Parameter	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
$ASC_{shared\ car}$	-0.529	0.00	-0.713	0.00	-3.06	0.00	-4.10	0.00
$\beta_{travel\ costs}$	-0.170	0.00	-0.267	0.00	-0.800	0.00	-0.843	0.00
$\beta_{walking\ time}$			-0.213	0.00	-0.482	0.00	-0.712	0.00
$\beta_{reservation}$					-0.592	0.05		
$\beta_{>20\ km}$	-0.487	0.00						
$\beta_{>40\ km}$			-0.543	0.00				
$\beta_{shopping}$	-0.853	0.00			-2.78	0.02		
$\beta_{visiting}$	0.367	0.01	0.892	0.00			2.69	0.01
$\beta_{<4\ days/week}$	0.530	0.00			2.45	0.03		
β_{women}			-0.287	0.02				
$\beta_{\geq 45\ years}$			0.463	0.00			1.78	0.03
$\beta_{oneperson/parent}$	-0.400	0.00						
$\beta_{t\ with\ children}$			0.408	0.00			1.65	0.04
$\zeta_{shared\ car}$					-6.66	0.00	6.09	0.00

Appendix D7: Intention to use the mobility hub (with attitudes/social norm)

Table D9: Estimation results MNL and ML model, intention to use the mobility hub

	Model	**MNL**				**ML – Error components**			
		Sample A		**Sample B**		**Sample A**		**Sample B**	
	# draws	N/A		N/A		1000		1000	
	# est. parameters	35		32		16		15	
	# observations	1354		1362		1354		1362	
	# individuals					412		415	
	Final log LL	-1671.378		-1633.658		-1147.362		-1066.856	
	Rho square	0.233		0.255		0.473		0.513	
	Adj. rho square	0.217		0.240		0.466		0.506	
Mode	**Parameter**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
All modes	$\beta_{walking\ time}$	-0.204	0.01			-0.701	0.00	-0.582	0.01
	$\beta_{no\ return\ needed}$			0.254	0.03				
	$\beta_{<1day/week}$	0.323	0.01					1.77	0.01
	$\beta_{statement1}$					-2.40	0.02		
	$\beta_{statement3}$					3.22	0.00	3.24	0.00
	$\beta_{statement5}$							1.72	0.05
	ζ_{hub}					4.34	0.00	-5.64	0.00
Shared car	ASC_1	-0.823	0.01	-2.09	0.00	-1.06	0.31	-5.40	0.00
	$\beta_{travel\ costs\ OM}$			-0.198	0.02				
	$\beta_{reservation}$	-0.306	0.02						
	$\beta_{known\ users}$	-0.569	0.00			-0.709	0.00		
	$\beta_{work/business}$	0.476^b	0.00						
	$\beta_{visiting}$			1.09	0.00				
	$\beta_{<1day/week}$			0.583^e	0.00				
	$\beta_{one\ parent}$			0.830	0.00				
	$\beta_{statement1}$	-0.853	0.00						
	$\beta_{statement3}$	1.18	0.00	1.26	0.00				
	$\beta_{statement4}$	0.378	0.03	-0.472	0.02				
Shared moped	ASC_2	-1.56	0.00	-2.97	0.00	-8.50	0.00	-9.58	0.00
	$\beta_{travel\ costs\ OM}$	0.452^c	0.00	0.327^c	0.00	0.555^c	0.00	0.671^c	0.00
	$\beta_{no\ return\ needed}$								
	$\beta_{>15km}$	-1.19^d	0.01			-4.65^d	0.00		
	$\beta_{work/business}$	0.476^b	0.00	0.862^d	0.00			1.81	0.05
	$\beta_{visiting}$	-3.22	0.00	1.79	0.00			2.65	0.02
	$\beta_{pickup,dropoff}$	-1.60	0.00						
	β_{women}	-0.543	0.01						
	$\beta_{\geq 45\ years}$	-0.645	0.00						
	$\beta_{high\ income}$	0.841	0.00	-0.833^d	0.00	2.55	0.02		
	$\beta_{not\ working}$	-0.813	0.00						
	$\beta_{one\ parent}$			0.957	0.01				
	$\beta_{statement1}$	-0.568	0.04						
	$\beta_{statement2}$	0.640	0.02						
	$\beta_{statement3}$			0.946	0.00				
	ζ_2					-6.15	0.00	3.56	0.00
Shared e-bicycle	ASC_3	-1.34	0.00	-1.85	0.00	-5.43	0.00	-9.45	0.00
	$\beta_{travel\ costs\ OM}$	0.452^c	0.00			0.555^c	0.00	0.671^c	0.00
	$\beta_{>10km}$			-0.542	0.00				
	$\beta_{>15km}$	-1.19^d	0.01			-4.65^d	0.00		
	$\beta_{work/business}$	0.476^b	0.00	0.862^d	0.00				
	$\beta_{shopping}$	-0.724	0.00						
	$\beta_{visiting}$			0.798	0.01				

	$\beta_{pickup,dropoff}$	-1.21	0.00	-0.491	0.05				
	$\beta_{<1day/week}$			0.583[e]	0.00				
	$\beta_{high\ income}$			-0.833[d]	0.00				
	$\beta_{together\ with\ childr}$	0.632	0.00	0.418	0.00				
	$\beta_{statement1}$	-1.18	0.00						
	$\beta_{statement3}$	1.02	0.00	0.454	0.00				
	$\beta_{statement4}$			-0.562	0.00				
	$\beta_{statement5}$			0.552	0.00				
	$\beta_{statement6}$			0.506	0.00				
	ζ_3					-6.11	0.00	-8.70	0.00
Shared e-cargo bicycle	ASC_4	-3.87	0.00	-3.86	0.00	-13.9	0.00	-15.5	0.00
	$\beta_{travel\ costs\ OM}$	0.452[c]	0.00			0.555[c]	0.00	0.671[c]	0.00
	$\beta_{no\ return\ needed}$								
	$\beta_{>5km}$	-0.820	0.00	-1.11	0.00				
	$\beta_{work/business}$	-2.15	0.00	-2.26	0.00				
	$\beta_{visiting}$	-1.22	0.01	1.51	0.00				
	$\beta_{<1day/week}$			0.583[e]	0.00				
	$\beta_{\geq 65\ years}$			-1.54	0.01				
	$\beta_{highly\ educated}$	1.22	0.00	1.80	0.00				
	$\beta_{t\ \ with\ children}$	1.65	0.00			6.78	0.00		
	$\beta_{one\ parent}$	1.47	0.00	-8.62	0.00				
	$\beta_{statement3}$			0.625	0.01				
	$\beta_{statement4}$	-0.926	0.00						
	$\beta_{statement5}$	0.732	0.00						
	ζ_4					-9.74	0.00	-9.20	0.00

[b] *same variable has been included in shared car, moped and e-bicycle*
[c] *same variable has been included in shared moped, e-bicycle and e-cargo bicycle*
[d] *same variable has been included in shared moped and e-bicycle*
[e] *same variable has been included in shared car, e-bicycle and e-cargo bicycle*

Appendix D8: Intention to use the mobility hub (without attitudes/social norm)

Table D10: Estimation results MNL and ML model (without attitudes/social norm), intention to use the mobility hub

	Model	MNL				ML – Error components			
		Sample A		Sample B		Sample A		Sample B	
	# draws	N/A		N/A		1000		1000	
	# est. parameters	27		24		14		13	
	# observations	1354		1362		1354		1362	
	# individuals					412		415	
	Final log LL	-1734.705		-1685.578		-1163.834		-1081.100	
	Rho square	0.204		0.231		0.466		0.507	
	Adj. rho square	0.192		0.220		0.460		0.501	
Mode	**Parameter**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**	**Value**	**p-value**
All modes	$\beta_{walking\ time}$	-0.197	0.01			-0.714	0.00	-0.597	0.01
	$\beta_{<1day/week}$	0.399	0.00					1.97	0.05
	ζ_{hub}					4.64	0.00	-5.91	0.00
Shared car	ASC_1	-1.05	0.00	-1.55	0.00	-1.12	0.00	-3.32	0.00
	$\beta_{travel\ costs\ OM}$			-0.182	0.03				
	$\beta_{reservation}$	-0.286	0.03						
	$\beta_{known\ users}$	-0.562	0.00			-0.699	0.00		
	$\beta_{no\ return\ needed}$			0.244[a]	0.03				
	$\beta_{work/business}$	0.431[b]	0.01						
	$\beta_{visiting}$			1.14	0.00				
	$\beta_{\geq 45\ years}$	0.385	0.03						
	$\beta_{one\ parent}$			0.863	0.00				
Shared moped	ASC_2	-1.58	0.00	-2.45	0.00	-8.47	0.00	-7.80	0.00
	$\beta_{travel\ costs\ OM}$	0.460[c]	0.00	0.336[c]	0.00	0.559[c]	0.00	0.686[c]	0.00
	$\beta_{>15km}$	-1.29[d]	0.00			-4.78[d]	0.00		
	$\beta_{work/business}$	0.431[b]	0.01	0.792[d]	0.00			1.87	0.04
	$\beta_{visiting}$	-3.26	0.00	1.83	0.00			2.67	0.01
	$\beta_{pickup,dropoff}$	-1.57	0.00						
	β_{women}	-0.545	0.00						
	$\beta_{\geq 45\ years}$	-0.547	0.00						
	$\beta_{high\ income}$	0.746	0.00	-0.884[d]	0.00	2.75	0.03		
	$\beta_{not\ working}$	-0.821	0.00						
	$\beta_{one\ parent}$			0.967	0.00				
	ζ_2					-6.07	0.00	3.80	0.00
Shared e-bicycle	ASC_3	-1.79	0.00	-1.52	0.00	-5.80	0.00	-7.28	0.00
	$\beta_{travel\ costs\ OM}$	0.460[c]	0.00			0.559[c]	0.00	0.686[c]	0.00
	$\beta_{no\ return\ needed}$								
	$\beta_{>10km}$			-0.579	0.00				
	$\beta_{>15km}$	-1.29[d]	0.00			-4.78[d]	0.00		
	$\beta_{work/business}$	0.431[b]	0.01						
	$\beta_{shopping}$	-0.716	0.00						
	$\beta_{visiting}$			0.831	0.00				
	$\beta_{pickup,dropoff}$	-1.12	0.00	-0.584	0.01				
	$\beta_{high\ income}$			-0.884[d]	0.00				
	$\beta_{t\ with\ children}$	0.628	0.00	0.510	0.00				
	ζ_3					-6.38	0.00	-8.38	0.00
Shared e-cargo bicycle	ASC_4	-3.80	0.00	-3.59	0.00	-13.5	0.00	-13.0	0.00
	$\beta_{travel\ costs\ OM}$	0.460[c]	0.00			0.559[c]	0.00	0.686[c]	0.00
	$\beta_{>5km}$	-0.752	0.00	-1.11	0.00				
	$\beta_{work/business}$	-2.11	0.00	-2.33	0.00				
	$\beta_{visiting}$	-1.13	0.01	1.49	0.00				

	$\beta_{\geq 65\ years}$			-1.55	0.01				
	$\beta_{highly\ educated}$	1.15	0.00	1.83	0.00				
	$\beta_{t\ with\ children}$	1.73	0.00			6.36	0.00		
	$\beta_{one\ parent}$	1.32	0.00	-8.64	0.00				
	ζ_4					-9.84	0.00	-9.11	0.00

[b] *same variable has been included in shared car, moped and e-bicycle*
[c] *same variable has been included in shared moped, e-bicycle and e-cargo bicycle*
[d] *same variable has been included in shared moped and e-bicycle*
[e] *same variable has been included in shared car, e-bicycle and e-cargo bicycle*

Appendix D9: Intention to reduce household car ownership & weighting of sample groups

Table D11 and Table D12 show the results of the intention to relinquish the (least used) car when the results are weighted based on the socio-demographic characteristics of the sample and the population. Table D11 includes all respondents without planned reductions before introducing mobility hubs, whereas Table D12 includes all respondents without (perhaps) planned reductions before introducing mobility hubs.

The weighting of sample to the population may potentially provide better insight into the effects. However, one should consider several drawbacks of weighting the sample to the population. Firstly, the survey was randomly distributed and addressed to households with at least one car. As a result, usually the head of the households completed the survey, which results in an underrepresentation of some sample groups (e.g. younger people) compared to the population. However, these underrepresented groups are also less likely to make decisions on the household level, which makes the weighting of these groups undesirable. Additionally, weighting of the groups may result in an overrepresentation of the groups that are less likely to own a car in their household, which is also undesirable. Secondly, the sample groups of some variable categories are relatively small. Consequently, deviations of individuals may have a large effect on the results. Overall, the weighting of the sample is undesirable when considering discussed drawbacks. Besides, the weighting of the sample would not lead to significantly different results.

Table D11: Probability of intention to relinquish the (least used) car in the case of weighting the sample to the population. Only respondents without planned reductions are included.

	Sample A (N=529)			Sample B (N=537)		
Variable	**No**	**Maybe**	**Yes**	**No**	**Maybe**	**Yes**
Gender	44.98%	35.40%	19.62%	51.07%	37.08%	13.36%
Age	40.63%	42.82%	16.56%	42.09%	49.58%	9.84%
Educational level	49.90%	32.39%	17.71%	54.85%	34.50%	10.65%
Household composition	46.32%	35.11%	18.58%	50.68%	37.69%	13.13%
Household income[a]	44.33%	32.87%	22.80%	46.84%	41.75%	15.76%
Sample (without weighting)	**45.56%**	**35.16%**	**19.28%**	**50.47%**	**36.31%**	**13.22%**
[a] People who do not know/want to say their household income are excluded from the weighting						

Table D12: Probability of intention to relinquish the (least used) car in the case of weighting the sample to the population. Only respondents without (perhaps) planned reductions are included.

	Sample A (N=440)			Sample B (N=466)		
Variable	**No**	**Maybe**	**Yes**	**No**	**Maybe**	**Yes**
Gender	52.26%	34.78%	12.97%	59.31%	37.37%	9.23%
Age	45.41%	42.40%	12.19%	50.37%	48.98%	6.55%
Educational level	55.62%	32.93%	11.45%	59.89%	33.46%	6.65%
Household composition	53.33%	34.17%	12.51%	58.28%	38.19%	9.44%
Household income[a]	52.45%	31.47%	16.08%	53.86%	43.60%	10.92%
Sample (without weighting)	**52.50%**	**33.86%**	**13.64%**	**55.79%**	**35.62%**	**8.58%**
[a] People who do not know/want to say their household income are excluded from the weighting						

Appendix D10: Association between intention to use and reduction (20 draws)

Table D13: Association between average of preferred/all alternatives and the intention to reduce car ownership

		Average of preferred alternatives				Average of all alternatives			
Sample	**Draw**	**No**	**Maybe**	**Yes**	**Corr.[a]**	**No**	**Maybe**	**Yes**	**Corr.[a]**
Sample A	1	-0.169	1.274	1.562	.168**	-0.897	0.910	0.989	.207**
	2	-0.160	1.247	2.366	.192**	-0.935	0.817	1.471	.228**
	3	0.253	1.355	2.205	.189**	-0.346	0.776	1.502	.177**
	4	-0.054	1.155	1.795	.186**	-0.766	0.788	1.293	.206**
	5	0.149	1.128	2.197	.165**	-0.807	0.667	1.361	.206**
	6	-0.103	1.280	2.153	.182**	-0.945	0.895	1.139	.218**
	7	0.160	0.866	2.700	.202**	-0.781	0.538	1.798	.222**
	8	-0.041	0.809	2.091	.216**	-0.637	0.367	1.552	.209**
	9	0.221	1.069	1.363	.127**	-0.717	0.837	0.932	.190**
	10	-0.030	0.978	1.132	.115**	-0.811	0.718	0.911	.196**
	11	0.242	1.124	1.943	.144**	-0.666	0.505	1.308	.193**
	12	-0.217	1.220	1.840	.170**	-0.761	0.747	1.040	.191**
	13	0.195	1.260	1.874	.160**	-0.503	0.869	1.188	.175**
	14	0.479	1.056	1.981	.150**	-0.350	0.756	1.167	.158**
	15	0.336	1.209	2.095	.149**	-0.488	0.791	1.369	.189**
	16	0.437	0.733	2.381	.142**	-0.428	0.536	1.539	.175**
	17	-0.011	1.703	1.840	.214**	-0.884	1.244	1.209	.249**
	18	0.247	1.442	1.688	.151**	-0.425	0.961	1.161	.169**
	19	-0.152	1.120	1.807	.208**	-0.754	0.607	1.197	.209**
	20	0.025	1.028	1.547	.137**	-0.763	0.583	0.800	.165**
	Mean	**0.09035**	**1.1528**	**1.928**	**0.16835**	**-0.6832**	**0.7456**	**1.2463**	**0.1966**
	S(mean)	**0.046721**	**0.049415**	**0.082566**	**0.00658238**	**0.043352**	**0.043485**	**0.055843**	**0.00516588**
Sample B	1	0.283	1.125	2.186	.114**	-0.520	0.767	1.459	.164**
	2	-0.159	0.526	2.131	.125**	-0.794	0.286	1.480	.166**
	3	0.112	0.840	2.035	.166**	-0.520	0.544	1.633	.177**
	4	0.084	1.091	1.794	.151**	-0.497	0.883	1.239	.175**
	5	0.101	1.198	2.249	.174**	-0.729	0.622	1.637	.196**
	6	-0.049	0.899	1.453	.132**	-0.554	0.500	0.994	.135**
	7	-0.140	0.707	2.415	.158**	-0.949	0.303	1.494	.181**
	8	-0.393	1.061	1.662	.185**	-1.033	0.678	0.947	.192**
	9	0.446	0.623	1.809	.109**	-0.178	0.177	1.381	.112**
	10	-0.053	0.985	2.432	.162**	-0.759	0.611	1.744	.188**
	11	0.195	0.795	2.083	.118**	-0.557	0.618	1.498	.170**
	12	0.093	0.392	2.502	.120**	-0.376	0.131	1.804	.132**
	13	-0.057	0.671	1.629	.119**	-0.723	0.517	1.173	.159**
	14	0.158	0.638	1.702	.098**	-0.381	0.369	1.346	.121**
	15	-0.015	0.848	1.990	.169**	-0.757	0.647	1.405	.199**
	16	0.298	0.685	2.323	.158**	-0.414	0.595	1.790	.183**
	17	0.017	1.087	2.046	.142**	-0.581	0.686	1.505	.179**
	18	0.042	0.575	2.288	.145**	-0.683	0.414	1.562	.175**
	19	-0.128	0.508	1.503	.126**	-1.058	0.178	0.912	.172**
	20	0.149	0.832	2.213	.119**	-0.493	0.396	1.804	.153**
	Mean	**0.0492**	**0.8043**	**2.02225**	**0.1395**	**-0.6278**	**0.4961**	**1.44035**	**0.16645**
	S(mean)	**0.041974**	**0.051843**	**0.071147**	**0.00553149**	**0.050779**	**0.046512**	**0.061329**	**0.00548753**

[a] *Kendall's tau-b correlation coefficient is based on all individual cases, * $p \leq 0.05$, ** $p \leq 0.01$*

Appendix D11: Association between intention to use & reduction (without attitudes/social norm)

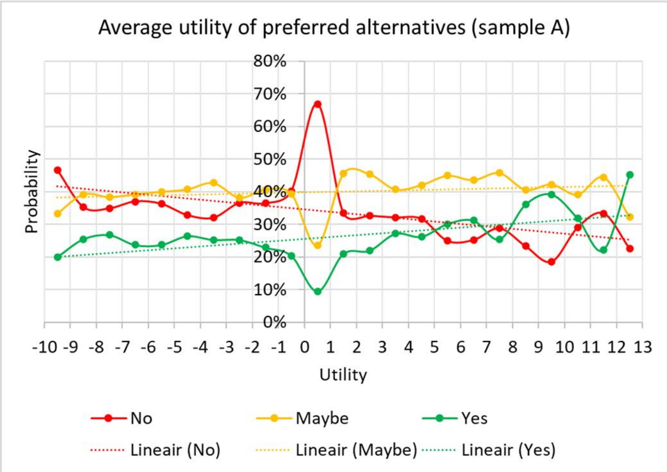

Figure D1: Probabilities of average utility of preferred alternatives, model without attitudes/social norm, sample A

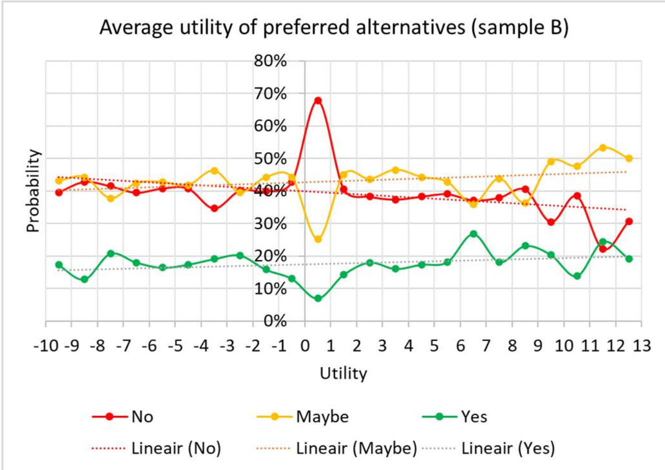

Figure D2: Probabilities of average utility of preferred alternatives, model without attitudes/social norm, sample B

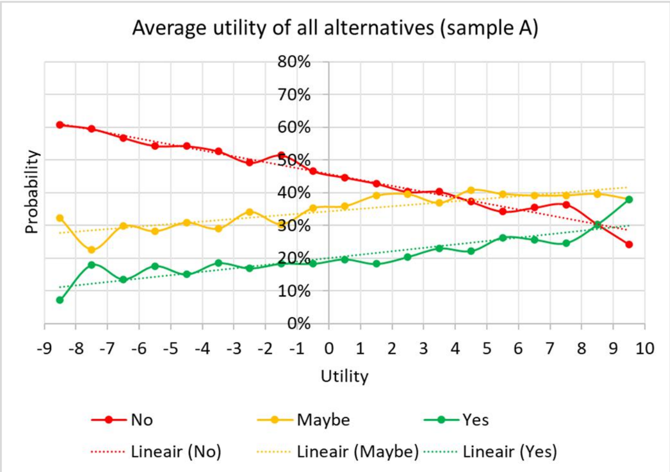

Figure D3: Probabilities of all utility of alternatives, model without attitudes/social norm, sample A

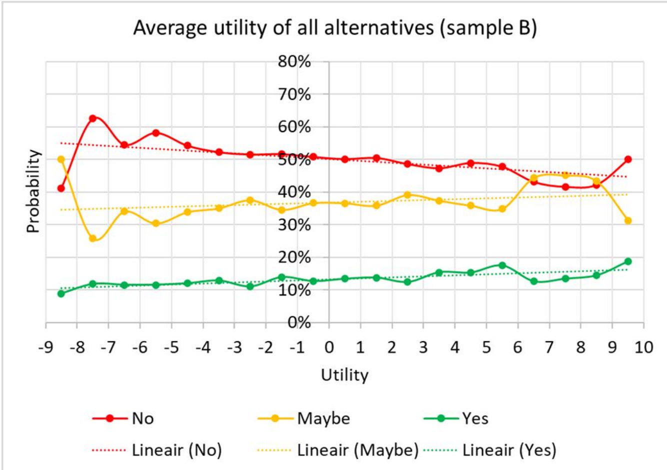

Figure D4: Probabilities of all utility of alternatives, model without attitudes/social norm, sample B