Mobility as a Service

in the *Paleiskwartier*

Explanatory factors for the intention to use and a process evaluation

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Mobility as a Service in the *Paleiskwartier*:
Explanatory factors for the intention to use and a process evaluation

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1. Preface

When I started looking for a subject for my master thesis graduation project, I definitely was looking for a subject that was related to technological developments in transportation. I am very glad that I have participated in the project *'Mobility as a Service in 's-Hertogenbosch'*, part of the research program *'De Mobiele Stad'*. From June 2018 on, I have been diving into the subject Mobility as a Service (which is often abbreviated as MaaS for the ease of use). After looking for the concept MaaS, the *raison d'être* of Maas and (potential) future implications of MaaS, I came to a specific research question formulation. Initially, I was looking for the changes in travel behavior and travel patterns of MaaS users, ex-ante and ex-post the introduction of Mobility as a Service in *het Paleiskwartier* in 's-Hertogenbosch. However, the progress of the operationality of MaaS went different than expected. I learned how difficult it is to set up a new mobility service from scratch on, within a spider web of different actors in the 'MaaS ecosystem', such as public transport companies, private MaaS integrators, mobility providers and public organizations.

Despite the fact that MaaS in 's-Hertogenbosch is still in development, I feel very satisfied with the results presented in this research. I shifted the research focus on the *why* residents and students in the *Paleiskwartier* have an intention to use MaaS and ridesharing, respectively. In addition, I investigated *how* the process of setting up a MaaS service went and *how* societal goals could be included in MaaS. The most intriguing aspect I learned throughout this whole process of setting up MaaS is that success is dependent on a strong collaboration and trust among involved actors. Also, it is important for all actors involved in Mobility as a Service to be as flexible as possible and to continuously adaptable to changes in technology, users and actors involved. Even on a weekly basis.

I would like to thank dr. Tiago Fioreze for his immense support during my research. Tiago, I really appreciated the discussions we had about all research related aspects, from theory, distribution of surveys to statistical analyses. Prof. dr. ing. Karst Geurs, thank you for your feedback during the lots of meetings we had throughout the last 6 months. You were able to take away my doubts and frustrations about the progress of the MaaS project, which was very beneficial to eventually deliver this product. I also would like to the thank the province Noord-Brabant for their support during my research. I appreciate the open culture within the organization and the forward looking perspective concerning (technological) developments in transportation. Special thanks to the members of the team *'Innovations in Public Transportations'*: Arwina, Bas, John, Naomi, Ellie, Linda and Kasper. Additionally, I would like to thank Ron Bos of the municipality of 's-Hertogenbosch, Liselotte Bingen of the Ministry of Infrastructure and Waterworks and two private MaaS integrators for their time and effort during the interviews held. Sacha Wijmer, thank you for all your help during the focus group interview in January 2019. Rosan Sengler, Pieter Brouwer and Oskar Eikenbroek, thank you for your help with the preparation of the resident-survey distributed on paper.

Last, I would like to thank my parents, Mark and Jolien, uncle and aunt, Bram and Marjan, friends, Robin and Sten, for their support when writing this master thesis. I have shared a lot of doubts, frustrations, but also achievements with you. Thank you.

Martijn de Gruijter **March 2019**

Executive summary

What is investigated in this research?
Mobility as a Service (abbreviated MaaS) is a relatively new concept in the 'world of mobility'. It is '*a mobility distribution model in which customer's major transportation needs are met over one interface and are offered by a service provider*' (Hietanen in Smith et al. (2018a)). MaaS could lead to more frequent use of transit and more multimodal travelling, as is concluded from the UbiGo and SMILE field trials. More case studies are needed to reveal what type of travelers have an intention to use MaaS and how many of them do really use MaaS. In addition, there is a strong need for reflection on the process of setting up a MaaS pilot. Both aspects are investigated for a MaaS pilot in the densely populated, inner-city located neighborhood the *Paleiskwartier* in 's-Hertogenbosch.

What explains the intention to use MaaS?
It is concluded that a fifth of the *Paleiskwartier* residents has an intention to use MaaS, mostly driven by positive attitudes towards MaaS. Potential MaaS users have a high preference to take the train to reach different destinations, do use the train on a (very) frequent basis and have the lowest car possession rates per capita. Semi-structured interviews with potential MaaS users (N=15) reveal that the added value of MaaS compared to separately available shared modes and transit is questioned. Socio-economic characteristics – such as income level, gender or age – do not significantly explain the intention to use MaaS, for *Paleiskwartier* residents. The intention to use ridesharing by *Paleiskwartier* students is predominantly driven by practical benefits, social aspects and cost savings.

Which barriers and opportunities are experienced throughout the process?
Concerning the inclusion of societal goals in Mobility as a Service (MaaS level-4), both private and public involved actors are concerned about the translation of societal goals and the absence of legitimacy to include societal goals in MaaS. An important barrier experienced is the lack of open data – and accompanied absence of a level playing field – between existing transit companies and MaaS integrators. The process of setting up Mobility as a Service in the *Paleiskwartier* is characterized by difficulties in the integration of different shared modes and accompanied delays. Actors involved indicate that commitment towards shared goals and trust are the most important factors for a vital collaboration in the future.

What is relevant to investigate in the future?
1. Why people use MaaS: it is relevant to investigate the amount of potential MaaS users in different socio-spatial contexts, based on the (possible) interaction between socio-economic characteristics and spatial configuration (i.e. residential self-selection).
2. The effect of MaaS: it is of relevance to estimate the effect of MaaS on modal shift, car possession rates and perceived usefulness ex-ante and ex-post the operational phase. This, to conclude if MaaS lead to desired outcomes (e.g. less use of the private car) and no adverse effects occur (e.g. shift from transit to shared car).
3. Stimulation mechanisms: Analysing the effect of different mechanisms towards MaaS users, such as gamification, on the stimulation of certain travel behavior. The effect could be investigated from the user, MaaS integrator and authority perspective.
4. Process evaluation: It is of relevance to investigate if the experienced barriers and opportunities for MaaS *Paleiskwartier* also hold for other MaaS pilots in the Netherlands. If this is the case, the role of transportation authority concerning the mitigation of perceived barriers – e.g. data policies or new forms of public-private cooperation – should be investigated.

Beleidssamenvatting

Wat is onderzocht?

Mobility as a Service (afkorting: MaaS) is een relatief nieuw concept in de mobiliteitswereld. Het is een '*distributiemodel van mobiliteit, waarin consumenten zo uitgebreid als mogelijk in hun vervoersbehoeften worden voorzien, middels een digitaal platform, georganiseerd door een mobiliteitsmakelaar*' (Smith et al., 2018a). De MaaS pilots UbiGo (Gothenborg) en SMILE (Wenen) hebben aangetoond dat MaaS gebruik van Openbaar Vervoer en multimodaal reizen stimuleert. Er zijn meer case study's nodig om te achterhalen welk 'type reiziger' en hoeveel reizigers een intentie hebben om MaaS te gaan gebruiken. Bovendien is het reflecteren op het process van het opzetten van een MaaS pilot vereist vanuit wetenschappelijk en beleidsmatig perspectief. Beide aspecten zijn onderzocht voor een MaaS pilot in het Paleiskwartier ('s-Hertogenbosch), een dichtbevolkte wijk, gelegen naast het station en de binnenstad.

Wat verklaart de intentie tot het gebruik van MaaS?

Éénvijfde van de bewoners van het Paleiskwartier heeft de intentie om MaaS te gaan gebruiken, vooral vanwege positieve attitudes aangaande MaaS. Potentiële MaaS gebruikers hebben een preferentie voor het gebruik van de trein om bestemmingen te bereiken, maken frequent gebruik van de trein en hebben het laagste aantal auto's per capita. De conclusie van een diepte-interview met 15 potentiële MaaS gebruikers is dat de toegevoegde waarde van MaaS ten opzichte van 'losse deelmodaliteiten' en OV betwist wordt. Sociaal-economische kenmerken – zoals inkomen, geslacht of leeftijd – leveren geen significante verklaring voor de intentie tot gebruik van MaaS, voor bewoners van het Paleiskwartier. De intentie tot gebruik van ritdelen door studenten wordt voornamelijk bepaald door praktische voordelen, sociale aspecten en besparing op (reis)kosten.

Welke barrières en voorwaarden worden ervaren gedurende het proces?

Aangaande de inclusie van maatschappelijke doelen (ook wel MaaS level-4), zijn zowel private als publieke actoren bezorgd over de afwezigheid van legitimiteit voor de vertaling van deze doelen binnen MaaS. Een barrière die ervaren wordt door de MaaS integrator is een gebrek aan open data vanuit OV-bedrijven: een gebrek aan een eerlijk speelveld voor MaaS integrators en OV-bedrijven. Het opzetten van MaaS in het Paleiskwartier is gepaard gegaan met technische moeilijkheden aangaande de integratie van verschillende deelmodaliteiten. Betrokken actoren geven aan dat gezamenlijke doelstelling en vertrouwen de belangrijkste voorwaarden zijn voor een vitale samenwerking.

Wat is relevant om te onderzoeken in de nabije toekomst?

1. Gebruik MaaS: zijn er verschillen in het aantal potentiële MaaS gebruikers in verschillende sociaal-ruimtelijke contexten? En is wat is het effect van de combinatie van sociaal-economische en ruimtelijke kenmerken op de intentie om MaaS te gebruiken?

2. Het effect van MaaS: op verandering in vervoerswijzekeuze, autobezit en gepercipieerd nut van de dienst, voor en na de introductie van MaaS, om te achterhalen of MaaS leidt tot wenselijke uitkomsten (bijv. verminderd autobezit) of dat ongewenste effecten optreden.

3. Stimuleringsmechanismen: het analyseren van verschillende sturingsmechanismen op gedrag richting MaaS gebruikers, zoals gamificatie. Dit vanuit het perspectief van de gebruiker, MaaS integrator en publieke organisatie.

4. Procesevaluatie: het achterhalen of de ervaren barrières en voorwaarden ook van toepassing zijn op andere MaaS pilots in Nederland. Wanneer dit het geval is, dan zal onderzocht moeten worden hoe de provincie haar rol kan aanpassen om deze barrières te mitigeren.

Scientific summary

Problem statement

The growing pressure on urban passenger transport systems has increased the demand for new and innovative solutions to increase its efficiency. The shift from 'owning' vehicles to 'sharing' vehicles – e.g. car sharing or bike sharing – could tackle this challenge. In combination with conventional public transportation, shared modes could serve as substitute to privately owned vehicles (Kamargianni et al., 2016). However, the complexity of using shared modes and transit offered by different companies – each having different payment methods and subscriptions – discourages many people from taking advantage of them. The digital integration between shared cars, shared bikes, ridesharing and public transportation could diminish the complexity of using them for travellers (Kamargianni , et al., 2016). The integration between ICT, shared mobility and public transportation: that is what Mobility as a Service is about.

What is MaaS?

Mobility as a Service – abbreviated MaaS – is '*… a mobility distribution model in which customer's major transportation needs are met over one interface and are offered by a service provider*' (Hietanen in Smith et al. (2018a)). Different from the private car, a single mode that is used to reach all destinations, Mobility as a Service could be seen as *'an umbrella of transport services'*: rail, bus, tram, metro, shared bikes and shared cars are included in one digital environment to facilitate individuals' needs for transportation (Smith et al., 2018a). The potential of Mobility as a Service to reduce car use and parking is subscribed by research of Karlsson et al. (2016): *'…results of the MaaS trial demonstrate the potential of introducing of new and innovative measures e.g. MaaS and hereby fundamentally changing the transport 'offer' and the relevance of so called hard measures to shift to more sustainable transport.'* (Karlsson et al., 2016, pp. 3271).

Why MaaS in the Paleiskwartier?

A MaaS pilot in the city 's-Hertogenbosch is investigated in this research. The urban context for the pilot investigated in this research is the neighbourhood *Paleiskwartier* (3,130 residents). It is characterized by its high building densities and mixed land-use and is located less than 1 kilometer from an intercity railway station. Two large educational facilities (28,500 students) and several companies are located in the neighborhood. With the development of new residential accommodations and offices, car accessibility and parking opportunities are under pressure in the near future (de Mobiele Stad, 2019). MaaS is initiated in the *Paleiskwartier* to investigate to what extent it could lead to a shift from private car use to the use of shared modes and transit and if MaaS could attenuate the pressure on car parking in the neighborhood. A commercial MaaS integrator "A" integrates all shared modes, transit and offers the application.

What is investigated in this research?

Revealing the factors that explain the intention to use Mobility as a Service is of relevance to estimate why *Paleiskwartier* residents are willing to use MaaS. Traveler segmentation is of relevance to estimate the magnitude of intended MaaS intended in the *Paleiskwartier*. It is not solely of relevance how many and why residents have an intention to use MaaS, but also which barriers and opportunities are experienced by public and private actors when setting up MaaS in the *Paleiskwartier*. From a scientific perspective, there is a need for reflection on the public-

private cooperation for MaaS, since the process of setting up MaaS is not widely investigated (Smith, et al., 2018a). From a policy perspective, this reflection on the public-private cooperation is needed to indicate positionality of the public transportation authority within the process (de provincie Noord-Brabant, 2018). The MaaS multilevel perspective of Mukhtar-Landgren et al. (2016) in combination with the Technology Acceptance Model (Davis, 1989) is used to answer the main research question:

Which factors explain the intention to use Mobility as a Service and which barriers and opportunities are experienced with the organization of Mobility as a Service?

Methodology

The main research question is distributed into five sub research questions. Four methods are used to answer all sub research questions:
(1) statistical tests on two datasets: resident-survey[1] (N=556) and student survey (N=202),
(2) a focus group interview (N=15),
(3) semi-structured interviews (N=6) and
(4) policy document analyses.

A door-to-door and digital survey is distributed among Paleiskwartier residents to reveal which factors determine the intention to use Mobility as a Service (sub research question 1). In-depth knowledge about the motivations (i.e. intentions) to use MaaS by residents is gained through a focus group among 15 residents (also part of sub research question 1). Information from the resident-survey is used for traveler segmentation (sub research question 2). For students, the intention to use ridesharing is investigated with a digital student-survey (sub research question 3). Six semi-structured interviews are held to reveal what expectations private and public actors have on the inclusion of societal goals in MaaS, enriched with policy document analyses (sub research question 4). Barriers and opportunities experienced with the organization of MaaS are also asked in the semi-structured interviews (sub research question 5).

Result 1: explanatory factors for the intention to use MaaS by *Paleiskwartier* residents

Based on ordinal logistic regression, it is concluded that the intention to use Mobility as a Service is mostly explained by positive attitudes of *Paleiskwartier* residents towards MaaS. Especially the interest in new mobility concepts (e.g. Uber), looking for travel alternatives for the private car and a positive attitude towards vending the private car when travel alternatives are available explain the intention to use MaaS. Also, the evaluation of healthy travelling and no mind travelling with unknown persons explain the intention to use MaaS. Residents evaluating flexible travelling as important, have a lower intention to use MaaS. Socio-economic factors – such as age, gender or income group – could not significantly explain the intention to use MaaS, for *Paleiskwartier* residents.

Result 2: magnitude of potential MaaS users among *Paleiskwartier* residents

It is concluded that approximately a fifth of the population is a potential MaaS user. Potential Maas users are characterized by positive attitudes towards MaaS characteristics, very frequent use of the train, preference to use the train for different trip purposes and low car possession

[1] For this research, the number of cases of resident-survey used for statistical analyses is 556 (November 2018). The complete resident survey dataset contains 568 cases (January 2019). No significant differences exist among both datasets, concerning results of statistical tests and conclusions.

rates. Also, the use of travel applications on a daily basis is the highest among all clusters. This implies that cluster 1 could be depicted as 'early adaptors' of MaaS. A large share of the population (clusters 2 and 4, i.e. 51.7%) is (very) unlikely to use Mobility as a Service. Approximately a third of the population is neither likely nor unlikely to use MaaS. Interestingly, this group has on one hand characteristics of typical MaaS users (i.e. multimodal travelling), but on the other hand not the socio-economic characteristics of typical MaaS users (i.e. high educated, young persons) and frequent use of travel planning applications.

Result 3: explanatory factors for the intention to use ridesharing by *Paleiskwartier* students

The intention to use ridesharing by *Paleiskwartier* students is mostly explained by practical benefits (i.e. avoiding the hassle of looking for a parking spot), social aspects (i.e. meeting new people) and the absence to possess a car if travel alternatives will be available. Flexibility is related vice versa: the more important a respondent evaluates flexibility, the lower the intention to use ridesharing.

Result 4: expectations of public and private actors on the inclusion of societal goals in MaaS (i.e. MaaS level-4)

Both public and private actors foresee difficulties in the inclusion of societal goals – such as reduced air pollution – in MaaS. First, there is a lack of legitimacy, since the public transport authority (PTA) has no legislative power to directly steer on behavior via a specific MaaS application. For example, the PTA indicates that it could not legally force MaaS integrators to include travel options aiming at a specific societal goal (e.g. low carbon travelling). Second, it is difficult to outweigh different societal goals by the public transport. For example, using shared cars with MaaS creates a specific basic of shared/public transportation for rural residents, but might also compete with transit (i.e. lower occupancy rates). Third, the translation of translation of societal goals into tangible travel advices is experienced as difficult by the PTA and MaaS integrator. For example, it is unclear what the effect – e.g. in terms of CO_2 reduction or societal inclusion – of different (financial) incentives within a MaaS application is. Even when the translation is possible, it is still unclear if travel advices lead to desired effects (i.e. the adoption rate by users).

Result 5: experienced barriers and opportunities in the process of setting up MaaS in the *Paleiskwartier*.

The private MaaS integrator "A" predominantly indicates that the lack of a level playing field between existing large private bus and rail companies and smaller private MaaS integrators. This barrier harms the private MaaS integrator to provide an affordable service to customers. This is evaluated as an 'inter-organizational barrier' (Smith, et al., 2018a). An unclear role division is experienced by the public transport authority and the PTA aims at a more steering role towards the private MaaS integrator in the future. A more steering role from the PTA is required since the private MaaS integrator lacked in transparency in the process, concerning the communication with other commercial parties and the organization of MaaS. Opportunities for a vital organization are trust, commitment towards shared goals and openness in distribution of data and information are the most important opportunities to smoothen the operation of MaaS.

To what extent are results (not) in line with literature on MaaS?
That the intention to use MaaS is mostly explained by positive attitudes towards MaaS, is in line with research of Karlsson et al. (2016) and *Kennisinstituut voor Mobiliteitsbeleid* (2018). However, the lack of significant explanatory power of socio-economic characteristics for the intention to use MaaS, is an important difference with literature on MaaS (in which younger, high educated, urban residents are more inclined to use MaaS). That it is expected that it is difficult to include societal goals in MaaS, is in line with Karlsson et al. (2017). Barriers and opportunities experienced with the organization are in line with research of Meurs et al. (2018).

Future research direction 1: Interaction between socio-economic characteristics and spatial configuration
One of the main conclusions is that socio-economic characteristics do not explain the intention to use MaaS, for *Paleiskwartier* residents. This might not hold for other spatial configurations, such as rural areas. It is not excluded that the interaction between socio-economic characteristics and spatial configuration, i.e. residential self-selection, might explain the intention (not) to use MaaS. The intention to use MaaS might highly relate with the added value of MaaS (i.e. temporal accessibility (Geurs & van Wee, 2004)), in different socio-spatial contexts. Future research could take the interaction between socio-economic characteristics and spatial configuration on the intention to use MaaS into account, for different case study areas.

Future research direction 2: changes in travel behavior due to the use of MaaS
When MaaS will be operational in the *Paleiskwartier*, changes in the factors explaining the intention to use MaaS could occur, such as mode choice, car possession and attitudes. It is of relevance to investigate to what extent the effect of MaaS is beneficial (e.g. a shift from private car to shared modes/transit) or adverse (e.g. a shift from transit to shared car). This, in combination with the motivations of users (not) to *use* MaaS and why users *stop* using MaaS, is of relevance to estimate the magnitude of the effect of MaaS on accessibility, equity and the environment.

Future research direction 3: steering mechanisms on travel behavior
It is of relevance to investigate which mechanisms stimulate MaaS users to act a certain travel behavior (with the deeper aim of realizing societal goals), and to what magnitude this stimulation reaches. Additionally, it could be investigated how public and private actors are up against using specific mechanism to stimulate certain travel behavior.

Future research direction 4: barriers and opportunities experienced in other pilots
Barriers and opportunities mentioned are only valid in the preparation phase of Mobility as a Service and might highly differ in the operational phase of MaaS in the future. Therefore, more case studies are needed to validate experienced opportunities and barriers. As been indicated by the involved actors, the opportunities are recognized, but the second step to concretize these opportunities is difficult. For a set of case studies, different possibilities – e.g. contracts, public-private collaborations – could be evaluated to realize these goals. In a similar manner, future research could focus on how the barriers experienced by public and private actors could be tempered, using different forms of collaboration.

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List of abbreviations and definitions

CBS	*Centraal Bureau voor de Statistiek* (Central Statistics Netherlands)
DRT	Demand Responsive Transport
Greenwheels	Rental car offered by the Dutch Railways
KiM	*Kennisinsituut voor Mobiliteitsbeleid* (Netherlands Institute for Transport Policy Analysis)
MaaS	Mobility as a Service
MaaS level-3	Integration of payment (bundling) with the mobility service offer
MaaS level-4	Integration of societal goals with the mobility service offer
MPN	*Mobiliteitspanel Nederland* (the Netherlands Mobility Panel)
MaaSiFie	MaaS project financed by the CEDR Transnational Road Research Programme 2014 on Mobility & ITS
NS	*Nederlandse Spoorwegen* (Dutch Railways)
NS Extra	Digital booking platform for door-to-door trips, offered by the Dutch Railways, including rail transport, NS Zonetaxi, OV-fiets and Greenwheels
NS Zonetaxi	Access/egress taxi to railway stations, offered by the Dutch Railways
OV-fiets	Public transport bike offered by the Dutch Railways
OviN	*Onderzoek Verplaatsingen in Nederland* (Research on mobility in the Netherlands)
PCA	Principal Component Analysis
PTA	Public Transport Authority (*provincie Noord-Brabant)*
SMILE	MaaS pilot in Vienna (2015)
UbiGo	MaaS pilot in Göthenborg (2015)
9292.nl	Digital booking platform for transit trips

Chapter 1

Introduction

The concept ‘Mobility as a Service’ is introduced, followed by the reason to have a Mobility as a Service pilot in the case study area. Hereafter, the societal and scientific relevance of this research is discussed. The chapter ends with the main research question and the structure of this research.

▲ Aerial view of the Paleiskwartier. In the centre the water basin on top of the parking garage.

1 Introduction

1.1 What is Mobility as a Service?

The growing pressure on urban passenger transport systems has increased the demand for new and innovative solutions to increase its efficiency. The shift from 'owning' vehicles to 'sharing' vehicles – e.g. car sharing or bike sharing – could tackle this challenge. In combination with conventional public transportation, shared modes could serve as substitute to privately owned vehicles (Kamargianni et al., 2016). However, the complexity of using shared modes and transit offered by different companies – each having different payment methods and subscriptions – discourages many people from taking advantage of them. The digital integration between shared cars, shared bikes, ridesharing and public transportation could diminish the complexity of using them for travellers (Kamargianni , et al., 2016). The integration between ICT, shared mobility and public transportation: that is what Mobility as a Service is about.

Mobility as a Service – abbreviated MaaS – is '*… a mobility distribution model in which customer's major transportation needs are met over one interface and are offered by a service provider*' (Hietanen in Smith et al. (2018a)). Different from the private car, a single mode that is used to reach all destinations, Mobility as a Service could be seen as *'an umbrella of transport services'*: rail, bus, tram, metro, shared bikes and shared cars are included in one digital environment to facilitate individuals' needs for transportation (Smith et al., 2018a). Research on carsharing, bike sharing and public transportation has been going on for decades, but research on Mobility as a Service has emerged since 2014, with the publication of articles on MaaS pilots in Sweden and Finland (i.a. the well-known UbiGo trial in Göthenborg (Sweden), see Sochor et al. (2015)). The potential of Mobility as a Service to reduce car use and parking is subscribed by research of Karlsson et al. (2016): *'…results of the MaaS trial demonstrate the potential of introducing of new and innovative measures and hereby fundamentally changing the transport 'offer' and the relevance of so called hard measures to shift to more sustainable transport.'* (Karlsson et al., 2016, pp. 3271).

Inherent to scientific research, the more is known about Mobility as a Service, the more questions arise (Sochor et al., 2015). These questions relate to user-oriented aspects – such as how to attract and satisfy MaaS users? – and institutional issues – which barriers are experienced with the organization of MaaS by public and private actors? As Sochor et al. (2017a) indicate, there is a strong need for reflexive research on Mobility as a Service pilots, with the following specific questions:

- Which factors explain the intention to use of MaaS?
- What traveler groups have a (dis)interest in using MaaS?
- Which barriers are experienced by public and private actors, when setting up MaaS?
- How could societal goals be included in Maas?

1.2 Mobility as a Service in the *Paleiskwartier*

A Mobility as a Service pilot in the city 's-Hertogenbosch is investigated in this research. The pilot is part of the research program *'Mobiele Stad'*, aiming at the development and testing of innovations for the integration of mobility and technology in the urban context. The urban context for the pilot investigated in this research is the neighbourhood *Paleiskwartier* (3,130 residents). It is characterized by its high building densities and mixed land-use and is located

less than 1 kilometer from an intercity railway station. Two large educational facilities (28,500 students) and several companies (345) are located in the neighborhood (CBS, 2017). With the development of new residential accommodations and offices, car accessibility and parking opportunities are under pressure in the near future (de Mobiele Stad, 2019).

MaaS is initiated in the *Paleiskwartier* to investigate to what extent it could lead to a shift from private car use to the use of shared modes and transit. MaaS could attenuate the pressure on car parking in the neighborhood, due to a shift from private car use to use of transit, ridesharing or shared cars/bicycles (Karlsson et al., 2016). Before this positive effect could be evaluated, the question rises how many residents an intention have to use Mobility as a Service, and for what reasons. The goal of this research is to reveal which factors explain the intention to use MaaS by *Paleiskwartier* residents and to evaluate the process of setting up MaaS. Since students are also a large group in the neighbourhood, factors explaining the intention to use ridesharing – part of MaaS – are investigated. The effect of MaaS on the car accessibility and parking pressure is not investigated, since the MaaS application is not operational at the moment of writing.

1.3 Relevance of the research

1.3.1 Why and how many people would use MaaS

Mobility as a Service could stimulate the shift from private car use to the use of public transportation and shared cars/bikes, as field trials in Göthenborg and Vienna have proofed (Karlsson et al., 2016). This shift towards more sustainable transportation due to the use of MaaS is expected to have several societal benefits. Examples are reduced need for parking space of the private car, improved livability of the neighborhood, improved accessibility and transport equity (RLI, 2016). Revealing factors that explain the intention to use Mobility as a Service is of importance to estimate why residents are willing to use MaaS. Traveler segmentation is of importance to estimate the magnitude of intended MaaS intended in the case study area. The combination of explanatory factors and traveler segmentation is beneficial for a targeted approach: *'… different groups have different pre-requisites and motives: one targeted approach or policy is not enough to affect the broad changes required to meet the challenges ahead.'* Sochor et al., 2015, pp. 8).

1.3.2 The organization of MaaS

It is not solely of relevance how many and why residents have an intention to use MaaS, but also which barriers and opportunities are experienced by public and private actors when setting up MaaS in the *Paleiskwartier*. From a scientific perspective, there is a need for reflection on the public-private cooperation for MaaS, since the process of setting up MaaS is not widely investigated (Smith, et al., 2018a). From a policy perspective, this reflection on the public-private cooperation is needed to indicate positionality of the regional government (i.e. the public transportation authority) within the process (de provincie Noord-Brabant, 2018). Also, on higher institutional levels, there is a need for reflection on the process of setting up MaaS (Ministerie van Infrastructuur en Waterstaat, 2018). That the public-private cooperation concerning the organization of MaaS often has obstacles, is subscribed by Karlsson et al. (2016): *'… the main obstacles seem to be found within and between companies and organizations. MaaS relies on cooperation and collaboration, on the notion of a co-operative and interconnected transport system (including services, infrastructure, information, and payment), where boundaries between not only transport modes are blurred but also between public and private operators.'* (Karlsson et al., 2016, pp. 3272). In line with literature on 'MaaS level-4' (see section 2.2), it is

investigated how societal goals – such as the stimulation of slow modes or transit – could be included in MaaS, from the perspective of the public transport authority and MaaS integrator. This is of relevance from a scientific perspective, since expectations on MaaS level-4 are barely investigated (Sochor et al., 2017a).

1.4 Main research question, sub research questions and used methodologies

In line with the investigation of the user-oriented and institutional aspects of MaaS, the main research question aims at answering which factors explain the intention to use MaaS and at evaluating the process of setting up MaaS:

Which factors explain the intention to use Mobility as a Service and which barriers and opportunities are experienced with the organization of Mobility as a Service?

Literature research (see chapter 2) is conducted to get notion of the subject Mobility as a Service and to provide a theoretical framework to answer the central research question (see the conceptual model in paragraph 2.7). The central research question is answered using five sub research questions (see paragraph 3.2), which are:
Sub research question 1: Which factors determine the intention to use Mobility as a Service by Paleiskwartier residents?
Sub research question 2: What traveller segmentation is of relevance concerning the intention to use Mobility as a Service?
Sub research question 3: Which factors determine the intention to use ridesharing by Paleiskwartier students?
Sub research question 4: What expectations do public and private actors have on the inclusion of societal goals in MaaS?
Sub research question 5: What opportunities and barriers are experienced by the MaaS integrator, public transportation authority regarding the organization of Mobility as a Service?

A mix of methods is used to answer the sub research questions: (1) statistical tests on two datasets retrieved from the resident-survey[2] (N=556) and the student survey (N=202), (2) a focus group interview (N=15), (3) semi-structured interviews (N=6) and (4) policy document analyses. A door-to-door and digital survey is distributed among Paleiskwartier residents to reveal which factors determine the intention to use Mobility as a Service (sub research question 1). In-depth knowledge about the motivations (i.e. intentions) to use MaaS by residents is gained through a focus group among 15 residents (also part of sub research question 1). Information from the resident-survey is used for traveler segmentation (sub research question 2). For students, the intention to use ridesharing is investigated with a digital student-survey (sub research question 3). Six semi-structured interviews are held to reveal what expectations private and public actors have on the inclusion of societal goals in MaaS, enriched with policy document analyses (sub research question 4). Barriers and opportunities experienced with the organization of MaaS are also asked in the semi-structured interviews (sub research question 5).

[2] For this research, the number of cases of resident-survey used for statistical analyses is 556 (November 2018). The complete resident survey dataset contains 568 cases (January 2019). No significant differences exist among both datasets, concerning results of statistical tests and conclusions.

1.5 Structure of this research

In **chapter 2**, the theoretical basis of Mobility as a Service is defined. MaaS is a socio-technical transition (Mukthar-Landgren et al., 2016) and comprise three institutional levels, of which the meso and micro level are analyzed. The conceptual model is presented in section 2.7. In **Chapter 3**, the five sub research questions are stated. Sub research questions 1 and 2 are related to the factors explaining the intention to use MaaS (for residents) and traveler segmentation concerning the intention (not) to use MaaS, respectively. Sub research question 3 answers the factors explaining the intention to use ridesharing by students. Sub research questions 4 and 5 answer the inclusion of societal goals in MaaS and evaluate the process of setting up MaaS, respectively. **Chapter 4** elaborates on the case study area – the *Paleiskwartier* – and used methodologies to answer the central research question. Statistical procedures (ordinal logistic regression and K-means clustering) are used to answer sub research questions 1, 2 and 3. Numerical results are enriched with an in-depth focus group interview with potential MaaS users (15 residents). Six semi-structured interviews with professionals and involved actors are used to answer sub research questions 4 and 5. In **chapter 5,** results for the five sub research questions are given. **Chapter 6** discusses all results with regard to theories presented in chapter 2. Recommendations for future research are presented. Outputs of the statistical procedures, focus group interview and semi-structured interviews can be found in the **Appendices**. Transcriptions of the interviews and focus group can be found in the **Addendum**.

Chapter 2

Theory and literature

This chapter describes the theoretical aspects of Mobility as a Service, thereby focusing on the definition of Mobility as a Service, organizational aspects, key stakeholders and lessons from previous MaaS field trials. The conceptual model used to answer the main research question is presented in the concluding section.

▲ Aerial view of the *Paleiskwartier*, the case study area. The neighbourhood is a brownfield development area, close to the intercity railway station and city centre.

2 Theory and literature

2.1 Definition of MaaS

Mobility as a Service is a '*mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider*' (Smith, et al., 2018a). Jittrapirom et al. (2017) define MaaS *'as a new way to provide transport, which facilitates the users to get from A to B by combining available mobility options and presenting them in a completely integrated manner.'* Giesecke et al. (2016) define Mobility as a Service from a socio-sustainable perspective, therein highlighting *'the importance of users' acceptance and adoption to MaaS, as well as its roles to transform their habits and behaviors to meet their travel needs in a sustainable way'* (Giesecke, et al., 2016) in Jittrapirom et al. (2017). Sustainability and equity in transport are taken into account for the definition of MaaS according to König et al. (2016) in Jittrapirom et al. (2017). '*MaaS offers need-based and customized mobility solutions for the users with the goal of achieving a more sustainable transport. This change of focus considers the social context to fulfill users' needs and environmental aspect while addressing the challenge of urban mobility. Implementing and delivering innovative services like MaaS will help to enhance accessibility and equity through a shift from ownership-based to access-based transportation.'* ((König, et al., 2016) in Jittrapirom et al. (2017)). Travellers' needs, route options and mode options are integrated with MaaS and results in (habitual) travel behavior, traveler satisfaction and accessibility of origins and destinations (see Figure 1).

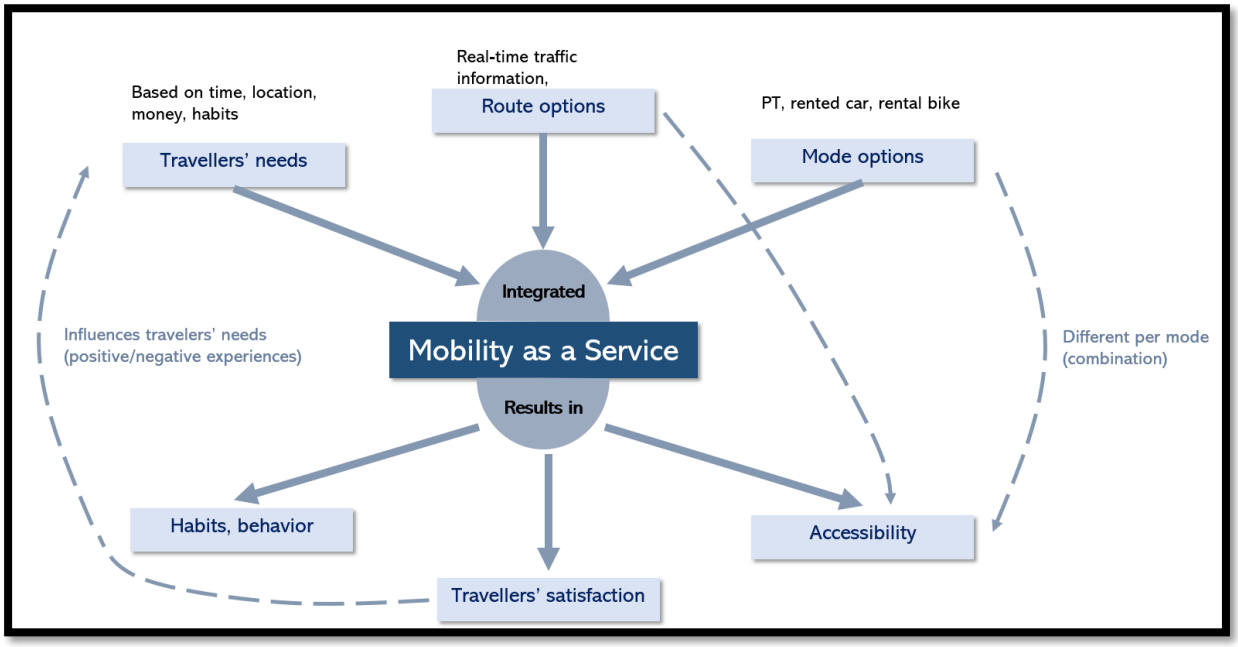


Figure 1 Mobility as a Service framework, based on its integration and results (based on i.a. Sochor et al. (2017a) and Jittrapirom et al. (2017)).

Mobility as a Service has three main attributes compared to *'conventional non-integrated mobility services*', which are (1) influence on travellers' decisions, (2) inclusion of other services and (3) mobility currency (Jittrapirom et al., 2017). The first attribute comprises the influence of MaaS to the behaviour of travelers. The second attribute comprises the inclusion of transport-related services, such as car sharing, ride sharing, park-and-ride, but also crowdsourcing and electric vehicles. The third attribute is digital cashflows that enable the user to use specific

mobility services. The user could earn digital coins (points) when specific goals are reached. The Whim application uses mobility currencies in its operation (Whim, 2018).

2.1.1 Typical MaaS characteristics

Sochor et al. (2015) state that three aspects characterize MaaS:

1. **Collective transport:** i.e. the integration of different transport services, public and private transport modes.
2. **'Sharing economy trend'**: the shift towards joined/shared ownership, rather than private/individual ownership.
3. **'ICT developments'**: developments in ICT, such as providing digital integration of mobility services or payment.

The degree of integration of mobility services is explained by Sochor et al. (2017a) by a 4-level 'MaaS ladder', which is explained in section 2.2.

2.1.2 Opportunities of MaaS

The European organization Polis – EU-wide city and region collaboration for innovative transportation solutions – states that Mobility as a Service provides five opportunities for users and governments (Polis, 2017):

1. the promotion of sustainable transport modes
2. improving the existing efficiency of transport modes
3. taking advantage of the personalized approach of transit
4. enhancing (digital) knowledge of public transportation
5. offering choices to users

MaaS could promote sustainable travel since the integration of services could reduce private car use (and ownership). This is due to the personalized travel information provision and by the facilitation of 'convenience to decide mode choice'. Existing efficiencies of (public) transportation modes could be increased by attracting more costumers to off-peak inner-city transit and transit in suburbs (both facing problems with the underutilization of transit). The personalized approach underlines the provision of tailored transport opportunities for all members of the society, e.g. MaaS could capture existing 'gaps' in accessibility for some persons. MaaS could enhance (digital) knowledge of public transportation since information about travel times, departures and so on could be easily presented to all travelers (Polis, 2017).

2.1.3 Potential risks for MaaS

Mobility as a Service is a relatively new concept and therefore could have some risks. The first risk is the shift from slow modes (walking and cycling) to motorized modes and from public to private modes (e.g. from bus use to shared cars). Mechanisms (such as pricing) could stimulate the MaaS user to take a specific mode. Another potential risk might be the public transportation operators refuse to participate in MaaS, since they are afraid to lose their position and costumers (Polis, 2017).

2.2 Levels of the MaaS ladder

The term 'integrated mobility services' is often used to describe MaaS, but this term only takes the information integration into account. An example of such an integration is the Dutch transit application *9292.nl* (providing real-time information about busses, trams, metros, trains and private buses such as FlixBus). However, regarding MaaS, this integration could be enriched with integrated payment, integrated booking and organizational integration. The levels of integration characterize the position of the service on the 'MaaS ladder', which is visualized in Figure 2 (Sochor, et al., 2017a).

2.2.1 Low levels of integration (level-0 and level-1)

Level-0 is traditional car rental, for example the rent of a car on a holiday. Level-1 comprises the integration of information, having multimodal travel information (e.g. 9292.nl or Google Maps). The difference with higher levels (2, 3 and 4) is that the users of the service are not consumers and that the organization providing the information is not responsible for the transport service (Sochor, et al., 2017a).

2.2.2 Information and payment integration (level-2 and level-3)

Level-2 comprises the integration of booking and payment of transport modes. The institution that organizes this integrated booking-and-payment is responsible for the transport service. Level-3 comprises the integration of mobility services, including booking and payment. The difference between level-2 and level-3 is difficult to capture, but essentially, MaaS level-2 comprises different MaaS organizers for different modes (e.g. the user have to use different platforms to arrange a shared bike-train trip), where in MaaS level-3 there is only one MaaS organizer. In level-3 there is (i) vice-versa responsibility of the user-supplier, (ii) focus on the 24/7 need of a household (schedules), (iii) non-transparency about the partial costs of a combined travel offer[3] and (iv) less difficulties in the ICT-integration of different transport organizations (Sochor, et al., 2017a).

2.2.3 Including societal goals in MaaS (level-4)

Level-4 comprises the full integration of mobility services, booking, payment and societal goals (e.g. transportation policies). The essence of MaaS level-4 is that the local/regional governments could influence the societal and environmental impacts of MaaS, for example by creating (financial) incentives for users to choose a specific mode. The 'government' that intervenes is a collaboration of the departments of spatial planning, transport and transit and the transit operators towards shared societal and environmental goals. Even if shared goals are reached, it might be difficult to provide the 'right' advice for MaaS users, based on retrieved data from different (governmental) organizations. In this sense, MaaS level-4 is the opposite of conventional transit: MaaS is a unified, flexible service, rather than a one-size-fits-all service with non-flexible prices. The integration of transit in MaaS level-4 should therefore not be based on fixed membership cards (e.g. monthly cards), but only the transit services should be included. Until nowadays, there are no concrete examples of MaaS level-4 pilots, but level-4 is an important point of discussion in scientific literature (e.g. (Karlsson, et al., 2017).

[3] the user cannot see what the different parts of the trip, e.g. shared car, transit, separately costs.

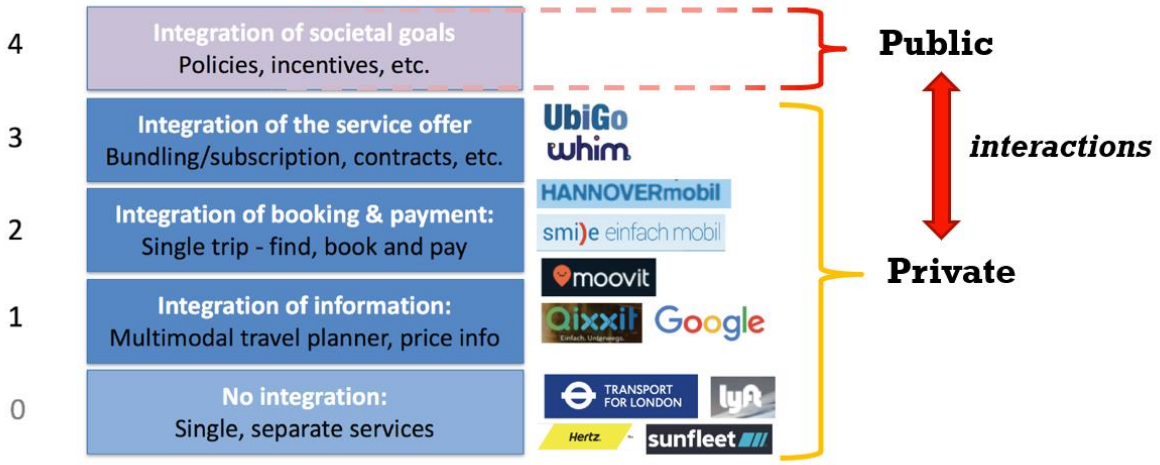


Figure 2 The Ladder of MaaS (retrieved from Sochor et al., 2017a).

Different from the four levels of MaaS defined by Sochor et al. (2017a), some other researchers use different definitions of the level of 'integration' within travel information and mobility services. For example, Kamargianni et al. (2016) do not include policy integration in their fourth level of MaaS (Kamargianni , et al., 2016). In this research, the four levels used by Sochor et al. (2017a) are used, because of its widespread citations and validity, and most important, since the Dutch national government explicitly mentions the integration of political and societal goals in Mobility as a Service as an important aspect of MaaS (Ministerie van Infrastructuur en Milieu, 2017). The importance of the fourth level of MaaS is recognized by the Ministry of Infrastructure and Waterworks in the report 'Market consultation Mobility as a Service (MaaS) in the Netherlands' (Ministerie van Infrastructuur en Milieu, 2017). *'With Mobility as a Service, the transport system could be more responsive, efficient and robust from a traveller perspective. Before this is reached, we have to learn a lot. For example, insight in the potential and effect [of MaaS] is needed, but also its limitations and complications.'* (Ministerie van Infrastructuur en Milieu, 2017, pp. 5, translated).

2.3 MaaS as a socio-technical transition

Mobility as a Service is an innovation in the transportation and mobility sector. Sochor et al. (2017a) argue that MaaS is a radical socio-technical innovation. This socio-technical transition is defined by Rotmans et al. (2001) as *'...a gradual, continuous process of change where the structural character of a society (or a complex sub-system of society) transforms'* (Rotmans, et al., 2001). A socio-technical transition could be seen from the user perspective or system perspective. From a user perspective, adoption and resistance factors determine the adaption of a new technology, based on Roger's theory of innovation diffusion (Claudy, et al., 2015). The perceived advantage, complexity, compatibility, trialability, and observability determine user's attitudes towards the innovation development (i.e. Mobility as a Service). From a system perspective, the process of the implementation of socio-technological innovations is best described by the institutional levels of MaaS presented by Mukthar-Landgren (2016), which has similar characteristics of the well-known multi-level perspective of Geels (2002), in which the macro-level sociotechnical landscapes are formed by the meso-level regimes and micro-level niche developments (Geels, 2002).

2.4 Institutional levels of MaaS

In analogy with the multi-level perspective introduced by Geels (2002), Sochor et al. (2017) and Mukthar-Landgren (2016) present three institutional levels of MaaS: (1) micro, (2) meso and (3) macro. The micro level describes individuals' travel characteristics, needs, and attitudes towards new forms of travelling. The meso level comprises the institutional organization of transport (the transit authority), but also the cooperation among the MaaS integrator, mobility providers, public transport companies and public organizations. The macro level comprises the national government with its laws and regulations. Institutions involved *'... comprise regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life'* (Mukthar-Landgren, 2016, pp. 10). This means that institutions do not solely comprise formal aspects (regulative features), but also informal aspects (normative and cognitive aspects, such as identity and perceived roles) (Mukthar-Landgren, et al., 2016). For the scope of this research, the macro level - the national government and its rules and regulations - is not analyzed. This, because regional government - responsible for the organization of conventional public transportation - is evaluated as a more relevant regarding the influence on MaaS for the pilot analyzed in this research. The micro level is analyzed to investigate what motivations potential users might have to adapt Mobility as a Service. The meso and micro level in relation with MaaS are explained in the next sections, see Figure 3 for a reading guide.

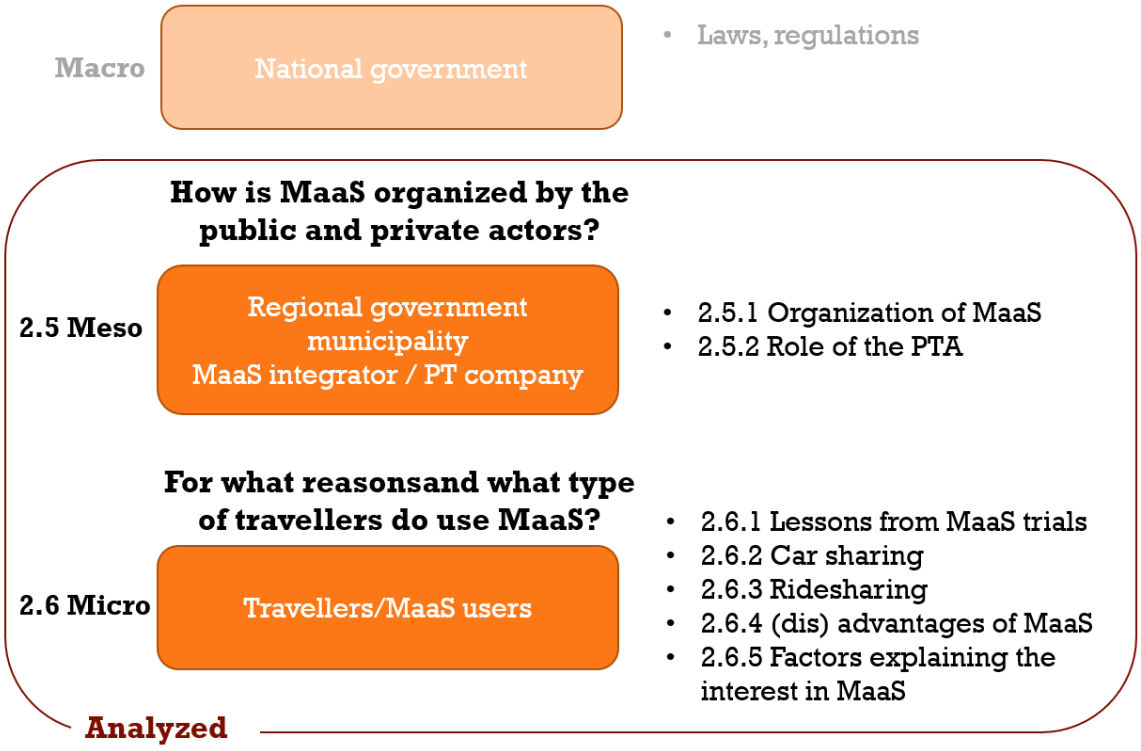


Figure 3 'MaaS multilevel perspective' by Mukthar-Landgren (2016). Only the meso and micro level are analysed in this research.

2.5 Meso level

The meso level comprises *'a variety of institutions: private, regional and local public, public/private hybrids and civil society organizations.'* (Mukthar-Landgren, 2016, pp. 15). Regarding Mobility as a Service for the pilot analyzed in this research, this includes public

transportation authorities, municipalities, MaaS integrator "A", citizen organizations, and companies/education institutions (the employers). The formal dimension of the meso level includes regulations, laws and (mobility) policies of the public transport authority (the province Noord-Brabant). Examples of formal influences are the legal power of the transport authority to provide possibilities for private parties to experiment with Mobility as a Service, but also by providing financial incentives (subsidies). Another example is the role of the local government in providing an adapted urban design for Mobility as a Service or parking regulations. The informal dimension of the meso level includes the 'stakeholders' visions towards MaaS: the public authority could have a different vision towards the goal of MaaS than private parties. For example, the public authority positions MaaS as an opportunity for reducing transport inequities, where private parties see MaaS as a business model to make profits. In addition to this, the informal dimension comprises the role division in the collaboration between the private and public stakeholder (Mukthar-Landgren, et al., 2016).

2.5.1 Organization of MaaS

In conventional public transportation, the transit authority (i.e. a Dutch province) defines the outline of transit lines, frequencies and fees. A transit operator is chosen using tendering, in which the transit operator fulfills all demands of the transit authority, for a time span of a decade (Provincie Noord-Brabant, 2018). The development of MaaS forces transit authorities to cooperate to a higher extent with the transport service providers, which are both existing public transportation companies, but also new mobility providers (i.e. the MaaS integrators and operators). In the framework in Figure 4, Mobility as a Service includes the (1) MaaS integrator - the actor that combines all different modes and routes - and the (2) MaaS operator - the actor that facilitates the application and payment (Smith, et al., 2018a). Regarding users, the difference is that users do not face one 'transit organization' (e.g. a bus company) as in traditional transit, but users face one 'MaaS Operator'. This MaaS Operator could for example be an application like UbiGo.

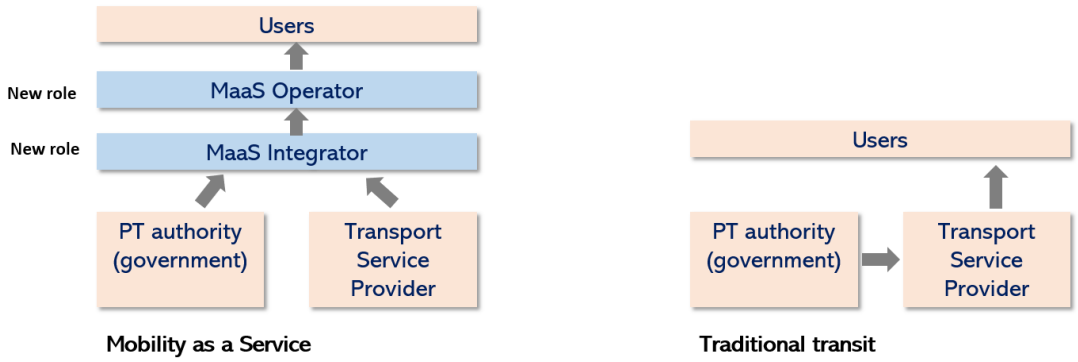


Figure 4 The organization of MaaS versus traditional transit organization (based on Smith et al. (2018a)).

2.5.2 Role of the public transport authority

Smith et al. (2018a) claim that MaaS is a *'socio-technical innovation process that involves the development and realization of creative ideas challenging conventional way-of-thinking and breaking with conventional practices'* (Smith, et al., 2018a). Realizing Mobility as a Service, public transport authorities (PTAs) need to apply 'open innovation' to the organizational aspects of MaaS. This means that transit authorities must either accelerate internal innovation having

targeted inflows of transport service providers (the PTA absorbs the role of the transport service provider). Otherwise, PTAs external innovation is needed, in which the PTA distribute role to external actors (inter alia the transport service providers). Related to open innovation is the role division of the public (transit authority) and private (transport service provider) in the MaaS organizational framework of. Smith et al. (2017b) propose that three type of role divisions for the public transportation authority and the transit operator are possible:

1. Market-driven development (the market fully initiates MaaS)
2. Public-controlled development (the PTAs are MaaS integrator and operator)
3. Public-private development (cooperation between PTAs and MaaS integrators/operators)

2.6 Micro level

The micro level comprises all individuals involved in Mobility as a Service (which are both end-users and indirect taxpayers). The role of those individuals in the micro level is defined as follows: *'Individuals as voters are included as democratic participators in deliberative planning processes and give feedback to decision-makers in terms of users of the urban landscape. The individual also figures in the rhetoric of political decision-makers, who motivate efforts with reference not only to values such as sustainability, but also in regard to the perceived needs and wants of citizens.*' (Mukhtar-Landgren et al., 2016, pp. 17). In this section, factors explaining the use of MaaS are explained, from the perspective of the user (i.e. the micro level). Two MaaS pilots are discussed.

2.6.1 Changes in travel behavior due to MaaS: results from two MaaS pilots

To best knowledge, three large MaaS field trials have been operational in the past: (1) Whim/MaaS Global in Helsinki and Antwerp (still 'live'), (2) 'UbiGo' in Göthenborg and (3) SMILE in Vienna. From an international perspective, one of the most extensively evaluated MaaS field trials is 'UbiGo' (Karlsson, et al., 2016), being part of the Go:Smart project in Göthenborg (Sweden) (Sochor, et al., 2015). The Go:Smart project aimed at '*creating a better opportunity for sustainable, urban travel, having a reduction of share of fossil-fuel vehicles and an increase of collective travel (i.a. transit) and reduced greenhouse gas emissions, thereby demonstrating how new business models and partnerships can reduce the need for private car ownership, in favor of these mobility services (MaaS).*' (Sochor et al, 2015, pp. 1). The UbiGo service aimed at bridging the gap between private and public transport modes, thereby taking the role as 'a broker of everyday travel'. One of the core characteristics of UbiGo was tailor-made transport services meeting individuals' traveler needs. One single subscription offered the client to make use of transit, taxis, rented cars, shared bikes and shared cars (Karlsson, et al., 2016). The UbiGo field operational test included 195 individuals (83 households, mostly couples without children) and was held between fall 2013 and spring 2014. Results of the field trial – on the micro-level – are:

- The advantage of having all travel alternatives ('travel package') is a clear environment, therefore providing clear alternatives to the private car to reach the destination
- Users think in a more extensive way about their transport alternatives from A to B. The MaaS application make the consideration for mode alternatives easier, but more in-depth
- Multimodality is better acknowledged by users: travelers do not see 'one mode' to reach the destination, but 'a combination of modes'
- Most of the participants that UbiGo reduced their travel costs (e.g. saving on unused monthly-transit cards or private car driving)

The Mobility as a Service pilot in Vienna (Austria) – called SMILE – has started in 2012 and lasted for more than three years. The operational phase of the pilot was one year and started in 2014 with approximately 1,000 participants. Half of the users were between 20 and 40 years old and the majority of the respondents (79%) was male. Car possession was moderate - 60% of the respondents owned a car – and three-quarter (77%) possessed a bike. The SMILE application was not used very frequently, only 30% of the respondents used the application on a weekly basis, 6% of the respondents used SMILE on a daily basis. The application was predominantly used for non-routine trips, such as leisure trips. This, because SMILE provided additional information to reach these non-routine destinations. Transit use was high by SMILE users: almost 90% of the respondents used transit on a regular basis – daily or several times per week. The most striking conclusions on the SMILE pilot in Vienna are (Karsslon, et al., 2017):

- 50% of the respondents indicate that their travel pattern changed
- 55% indicate that they combine more transport modes, more often than before
- 60% indicate that they discovered new routes during their leisure trips
- 50% indicate that they used transit more often
- 20% indicate that they used their private car less

Results of the UbiGo trial in Göthenborg and the SMILE pilot in Vienna indicate that Mobility as a Service contributes to higher use of multimodal trips, higher use of transit and a lower use of the private car. MaaS provides a transparent insight in multimodal travel alternatives, which makes it easier for the consumer to use – for example – transit or shared car. In addition, sharing economies and ICT (new technologies) highly characterize Mobility as a Service. (Sochor et al., 2015; Karlsson et al., 2017).

2.6.2 Car sharing and its users

In this section, characteristics of car sharers and factors determining car sharing are discussed. Car sharing could be seen as a facet of Mobility as a Service (it is not MaaS, since there is no integration with other modes) and therefore provides important information regarding factors determining the use of shared cars in a Mobility as a Service environment (Kamargianni , et al., 2016). The sharing economy trend, type of car sharers and institutional factors regarding car sharing are discussed in this section. Regarding the 'sharing economy trend', research of the *'Kennisinstituut voor Mobiliteitsbeleid'* has investigated the motivations for car sharing. Conclusions are that car-sharers mainly use the shared car (compared to the privately owned car) (Kennisinstituut voor Mobiliteitsbeleid, 2015):

- To save costs: paying for using rather than owning
- For the ease of use: no hassle with maintenance or cleaning

Other motivations are that shared cars are quicker than conventional transit. The use of shared cars is in most of the cases not from an environmental perspective, but from a financial perspective done by its users (Kennisinstituut voor Mobiliteitsbeleid, 2015).

Taking the case of car sharing in the Netherlands, car sharers are mainly highly educated men (between 30-40 years), living in high-density urban environments. Regarding the type of family composition, (young) couples without children make most use of shared cars (Kennisinstituut voor Mobiliteitsbeleid, 2015). The *'Kennisinstituut voor Mobiliteitsbeleid'* state that potential car sharers mostly 'high educated persons, having no children' (both men and women). An important side note is that the respondents in the research use shared cars very often per year

(more than half use the shared car less than three times a year from a commercial organization). Concerning travel motives, shared cars are mostly used for visiting friends and family (25%), shopping (15%) recreation (15%) and business (15%), mostly for distances between longer than 50 kilometers (Kennisinstituut voor Mobiliteitsbeleid, 2015). These large distances accompany the travel motives of car sharers. Preferences for characteristics of shared cars are (1) low costs (0,30 euro/km), (2) maximum 5 minutes walking distances to pick-up point, (3) no fixed pick-up/drop-off point, (4) reserved parking lot and (5) an electric shared vehicle (Dieten (2015) in *Kennisinstituut voor Mobiliteitsbeleid* (2015)). Regarding the pilot in the *'Paleiskwartier'*, the shared car could serve different trip motives and attract type different users than the research of the *'Kennisinstituut voor Mobiliteitsbeleid'* (2015) indicated since the scope and purpose of the pilot in the *'Paleiskwartier'* is different.

Research of Kim et al. (2017) reveals that success of car sharing depends on '*making car sharing more attractive for users using profound insight in people's decision-making behavior to join a car-sharing organization*' (Kim et al., pp 30). The availability of the shared cars is the most important factor that determines the degree that people are willing to join a car-sharing organization. Interestingly, Kim et al. (2017) foresee a complementary role for the shared car (so no substitution of existing transport modes). Regarding payment, the monthly payment and payment per kilometer driven are the most appreciated by the users. Last, car sharers are more inclined to avoid buying a second car but do not replace their 'first car' (Kim, et al., 2017).

2.6.3 Ridesharing

Another facet of Mobility as a Service is ridesharing. Ridesharing in a MaaS ecosystem is described as *'…an automated system made available by a ride-share provider which matches up drivers and riders for a specific route.'* (Agatz et al., 2012, pp. 295). Ridesharing is appealing from the perspective of a door-to-door modality (such as the privately-owned car), having higher occupancy rates than mostly one-person driven private car, which benefits the environment and saves costs (Agatz, et al., 2012). The Dutch '*Kennisinstituut voor Mobiliteitsbeleid*' (KiM) did a literature review on Mobility as a Service and travel preferences for the Netherlands. For ridesharing specifically, the *KiM* concludes that ride sharing has a bilateral effect on transit use, would decrease active mode use, decrease private car use and reduce car ownership for frequent car users. The amount of vehicle kilometers travelled will increase due to ridesharing. These conclusions are based on a multi-review on scientific papers (Kennisinstituut voor Mobiliteitsbeleid, 2018). Concerning the users of a ridesharing service, the *KiM* distinguishes two subgroups:

1. Incidental users: those use ridesharing for non-frequent trips.
2. Frequent users: those using ridesharing on a more regular basis, but only persons who are inclined to be an 'innovator' or 'early adopter'.

The KiM concludes in its literature review that the adoption of ridesharing is higher on the following target groups (Kennisinstituut voor Mobiliteitsbeleid, 2018):

- Young adults
- High educated persons
- Urban residing persons
- Childless persons
- A low rate of car ownership

Convenience, reliability and shorter travel times (compared to transit) characterize an intention to use ridesharing. Compared to driving, the avoidance of drunk driving and the absence of parking stress are mentioned as factors that explain the intention to use ridesharing (Kennisinstituut voor Mobiliteitsbeleid, 2018). Within the focus of this research, ridesharing will be available for students of universities in the case study area. Research of Tezcan (2016) in ridesharing among students indicate that the residing location of the students is an important factor determining the use of ridesharing. The following factors are of relevance: (1) location of the pick-up and drop-off, (2) timeframe (e.g. the pick-up and drop-off time), (3) guarantees in trip offering and (4) costs.

2.6.4 Perceived (dis)advantages of Mobility as a Service

The *Kennisinstituut voor Mobiliteitsbeleid (KiM)* – has conducted three focus group conversations about the ex-ante interest in Mobility as a Service, with a focus on the perceived (dis)advantages of MaaS (Kennisinstituut voor Mobiliteitsbeleid, 2018). Perceived advantages – with respect to the travel pattern of individuals – of Mobility as a Service are:

- A comprehensible overview of travel alternatives
- Less hassle than the use of several conventional travel planning applications
- Expected savings in travel costs and payment possibilities (e.g. subscriptions)
- Choice freedom and flexibility

MaaS is a more user-friendly travel application, since users are fully assisted by their trip from A to B, with a very transparent insight in travel costs, travel time, transfers and route alternatives. These features are an enrichment of existing (transit) planning applications, which makes conventional transit more attractive for respondents. Maas also enables the flexibility of travelling, in terms of mode choices and payment possibilities. Respondents indicate that this flexibility stimulates the integration of different modalities, such as transit and shared cars (Kennisinstituut voor Mobiliteitsbeleid, 2018).

Perceived disadvantages of MaaS – indicated by the focus group conversations – are:

- Dependence of the system (e.g. the planning application)
- Dependence of subscriptions

These perceived disadvantages are related to dependencies on the system, in terms of reliability and required planning skills. As some respondents indicate, if they would be *fully* dependent on Mobility as a Service, then it would require a lot of ex-ante planning for their daily trips (Kennisinstituut voor Mobiliteitsbeleid, 2018). Respondents also indicate that they are only interested to use MaaS on an infrequent basis, which is also seen in the SMILE pilot in Vienna (59% of the MaaS trips were non-routine trips (Karsslon, et al., 2017). Financial dependencies, such as the non-use of MaaS, but still having to pay for the service, is also perceived as a disadvantages by respondents (Kennisinstituut voor Mobiliteitsbeleid, 2018).

2.6.5 Acceptance of technology

Use of new technologies – like MaaS – highly depend on the acceptance of users. The Technology Acceptance Model (TAM) is developed to estimate the adaption of new technologies. Two central factors influence this adaption rate: (1) the perceived ease of use and (2) perceived usefulness (Davis, et al., 1989). The perceived ease of use is: "*… the degree to which the user expects the target system to be free of effort*" (Davis et al. 1989, p. 985). The perceived

usefulness is defined as "*the user's subjective probability that using a specific application system will increase his or her job performance within an organizational context*" (Davis et al., 1989, p. 985).

2.7 Conceptual model

Based on the research of the *Kennisinstituut voor Mobiliteitsbeleid* (2018) and the results of the MaaS field trials in Göthenborg and Vienna (Karlsson et al., 2016), the intention to use MaaS could be explained by the following factors:

- Attitudes towards MaaS specific characteristics
- Perceived usefulness of MaaS
- Evaluation of travel aspects
- Actual mode use
- Car possession rate
- Use of ICT / smartphone
- Socio-economic characteristics
- Spatial configuration
- Perceived ease of use

See Figure 5 for a visualization of the elements of the conceptual model. It is assumed – based on the literature review in paragraphs 2.1 – 2.6 – that the factors mentioned above have an influence on the intention to use MaaS, for the micro level (potential users of MaaS). For the macro level, interactions among involved private and public actors exist for the field trial (see 2.5). In addition, the translation of societal goals (MaaS level-4, see 2.2.3) by the public transport authority is part of the meso level.

2.7.1 The meso level of the conceptual model

For the meso level, possibilities and barriers concerning the setting up of Mobility as a Service are analyzed for all involved stakeholders. In addition, the institutional inclusion of MaaS is investigated, being part of the meso level of the framework of Mukthar-Landgren et al. (2016). Sub research questions 4 and 5 are related to the meso level of the conceptual model (see 3.2.4 and 3.2.5).

2.7.2 The micro level of the conceptual model

Concerning the micro level, the intention to use MaaS and ridesharing is investigated, for *Paleiskwartier* residents and students, respectively. It is important to note that the *intention* to use MaaS is investigated, not the *interest* solely. The intention to use a service indicates a higher degree of willingness to use it, than the interest solely. Seven out of nine explanatory factors are investigated: the effect of spatial configuration on the intention to use MaaS could not be investigated since the spatial configuration of the *Paleiskwartier* is uniform in terms of building densities and land-use. The 'perceived ease of use' could not be investigated, since the MaaS application is not operational at the moment of writing. It is assumed that testing the MaaS application reveals the 'perceived ease of use', which on its turn determines the actual use of MaaS.

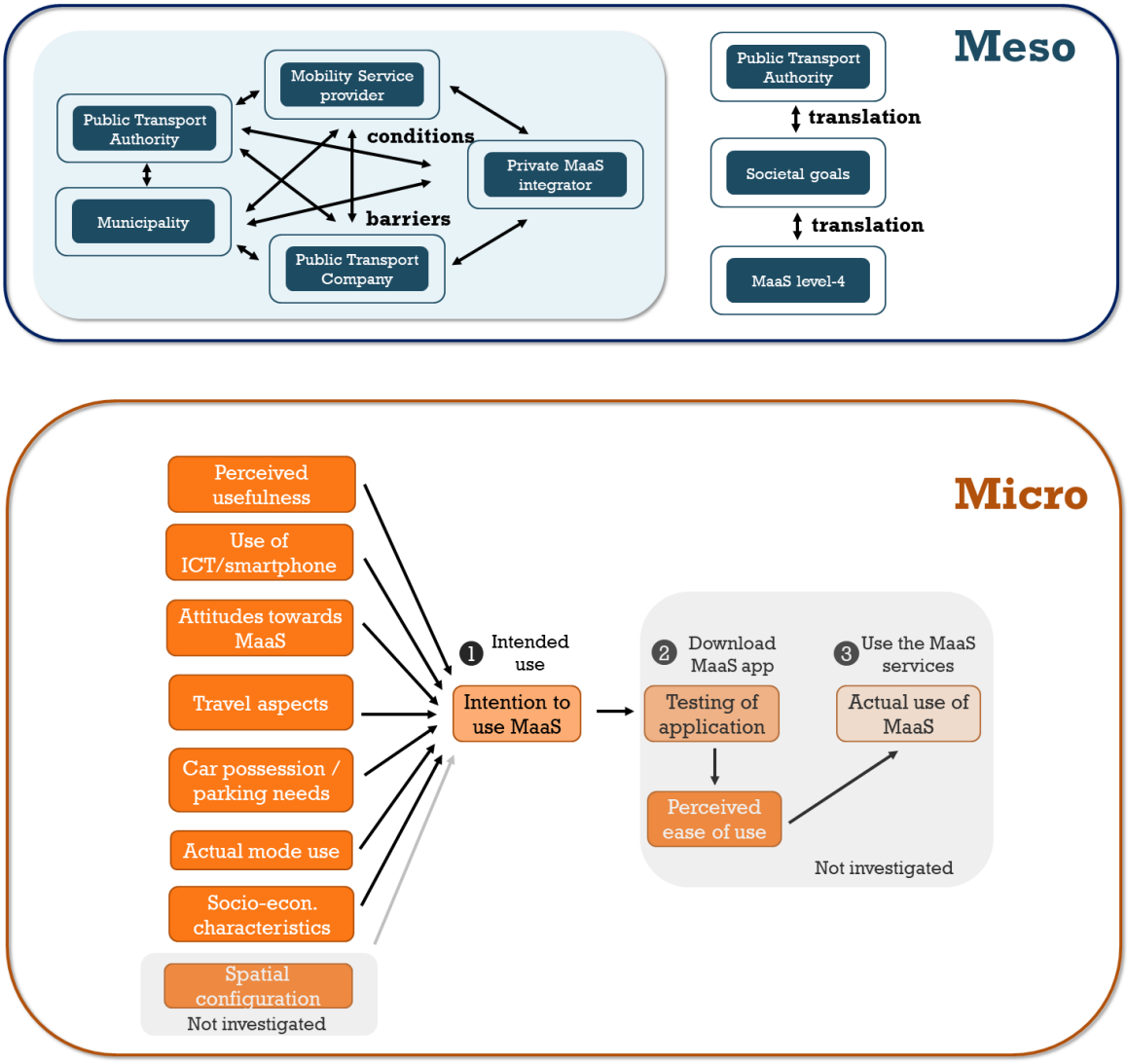


Figure 5 Conceptual model, used to answer the central research question.

Attitudes towards MaaS could be derived from the MaaS specific characteristics, which are the four C's (*costs savings, convenience, choice freedom and customization*), contribution of MaaS to sustainable travel and flexible travel (Kennisinstituut voor Mobiliteitsbeleid, 2018). Attitudes '*…reflect on how positive or negative persons evaluate a particular action.*' (van Wee, 2013, pp. 29). Attitudes are based on the importance of factors for an individual - for example, the freedom of the privately-owned car – and personal beliefs that a specific behavior will result in the desired outcome (van Wee, et al., 2013). Highly related with the attitudes towards MaaS specific characteristics is the 'perceived usefulness' of MaaS: the added value of MaaS for an individual traveller (Davis et al., 1989). Actual mode use is an important predictor of the interest in Mobility as a Service, since frequent transit users are more inclined to use MaaS, compared to frequent car users (Kennisinstituut voor Mobiliteitsbeleid, 2018; Karlsson et al., 2017). In line with this, car possession rates are important predicators of the intention to use carsharing and transit (Kennisinstituut voor Mobiliteitsbeleid, 2018).

The use of ICT and smartphone is an important predicator of the interest in MaaS, based on empirical findings of the MaaS pilots UbiGo and SMILE and the research of *Kennisinstituut voor Mobiliteitsbeleid* (2018). This, because MaaS requires adroitness using a smartphone (e.g. to plan the trip from A to B). Also, socio-economic characteristics are of importance, since younger, high educated people are more inclined to use MaaS than older or lower educates people (cf. Karlsson et al., 2017; Sochor er al., 2015).

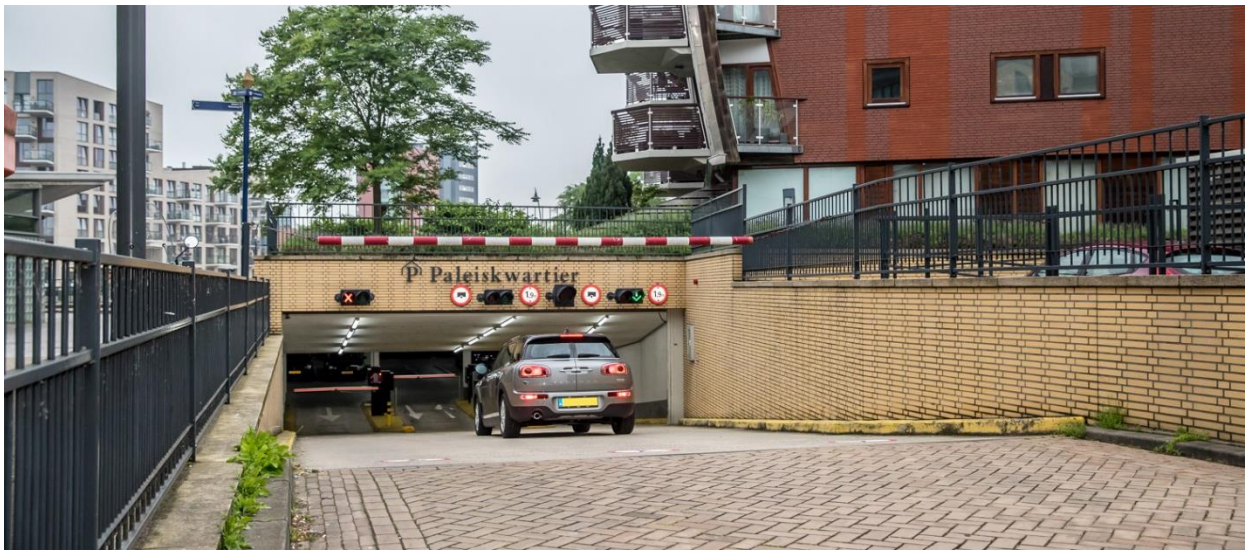
2.8 Summary

Mobility as a Service is a '*mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider*' (Smith, et al., 2018a). Perceived advantages of using MaaS are a comprehensible overview of travel alternatives, flexibility, choice freedom and expected travel cost savings (Kennisinstituut voor Mobiliteitsbeleid, 2018). In this research, the meso and micro level of MaaS are analyzed, for a MaaS pilot in the *Paleiskwartier*. For the meso level, possibilities and barriers concerning the setting up of Mobility as a Service are analyzed for all involved stakeholders. In addition, the institutional inclusion of MaaS is investigated. Results can be found in chapter 5. Concerning the micro level, the intention to use MaaS and ridesharing is investigated, for *Paleiskwartier* residents and students, respectively. Based on field experiences with MaaS, the intention to use MaaS could be explained by attitudes towards MaaS, evaluation of travel aspects, actual mode use, car possession rates, use of ICT, socio-economic characteristics and the perceived usefulness (Kennisinstituut voor Mobiliteitsbeleid, 2018) (Karlsson, et al., 2016) (Davis, et al., 1989). To what extent these factors actually contribute to the intention to use MaaS is questioned in chapter 3 and answered in chapter 5.

Chapter 3

Research questions and case study area

The main research question and five sub research questions are mentioned. Used methodologies to answer these sub questions are described. The spatial configuration of the case study area is described.



▲ Parking garage in the *Paleiskwartier*. The garage has room for more than 1,000 cars.

3 Research questions and case study area

3.1 Main research question

As been stated in 1.2, the goal of this research is to reveal which factors explain the intention to use MaaS and ridesharing, by *Paleiskwartier* residents and students respectively, and to evaluate the process of setting up MaaS. The main research question is:

Which factors explain the intention to use Mobility as a Service and which barriers and opportunities are experienced with the organization of Mobility as a Service?

The main research question aims at stating the factors that explain the intention to use Mobility as a Service for *Paleiskwartier* residents (*read 'ridesharing' for students, see 3.4.1*). The explanatory factors that are investigated in this research are based on the conceptual model and are focused on the *intention* to use MaaS (N.B. not the *interest)*, see Figure 5. It is not only investigated why people have an intention to use MaaS, but also what share of the Paleiskwartier residents actually have an intention to use MaaS. Experienced barriers and opportunities with the organization of the MaaS pilot are investigated. Answering the central research question, five sub research questions are answered (formulated in 3.2.1 – 3.2.5). For each sub research question, the reasons for asking and used method(s) are mentioned.

3.2 Sub research questions

3.2.1 Sub research question 1: Which factors determine the intention to use Mobility as a Service by Paleiskwartier residents?

The first sub research question has relation with the micro level of the conceptual model. Paleiskwartier residents are asked about their intention to use Mobility as a Service in the ex-ante survey. In this survey, all relevant factors of the conceptual model (see Figure 5) are asked. This, to test to what extent the factors significantly could explain the intention to use MaaS. A complete description of the survey can be found in 4.2. The central question of the survey – being the dependent variable of the statistical methods – is the intention to use MaaS. This is formulated as ''*If MaaS would be introduced, how likely is it that you will use MaaS?*' [1 very unlikely – 5 very likely]. This statement is specifically formulated to test how likely travellers are to *use* MaaS, thereby revealing their true intention, rather than interest solely. Ordinal logistic regression analysis will be used to determine which factors significantly influence the probability in using MaaS (see 4.3.3 for a description of this method). In addition, a selection of potential MaaS users – those indicating to be (very) likely to use MaaS – will be asked with a focus group interview about their motivation(s) to use MaaS. A focus group is used to go deeper into possible motivations to use MaaS than could be retrieved from the survey solely (see 4.6). Sub research question 1 is answered in section 5.1.

3.2.2 Sub research question 2: What traveller segmentation is of relevance concerning the intention to use Mobility as a Service?

The second sub research question has relation with the micro level of the conceptual model. Traveller segmentation is used in to estimate meaningful sub groups of individuals or objects. It is used to reduce the amount of single entities by creating meaningful and tangible homogenous sub groups. Traveller segmentation is used to estimate the intention to use Mobility as a Service and provides opportunities a more targeted policy or commercial approach (Anable, 2005). Bingen (2017), in compliance with Sochor et al. (2017a) and Karlsson

et al. (2017) state that: '*… more case studies are needed to analyze which spatial, socio-economic and socio-psychological factors determine the use of Mobility as a Service and which 'traveler' segmentation is feasible to apply for the tendency to use MaaS'*. These factors indicate the extent to which a specific traveler group is willing to adopt an innovation such as Mobility as a Service. Clustering enables to derive *'… significant criterion variables which segregate different groups.'* (Bharadwaj & Satis, 2015, pp. 5). It is therefore possible to distinguish different traveler personae (the clusters) based on different common variables. Two-step cluster analysis is used for traveller segmentation. First, hierarchal clustering is runned to determine the amount of 'meaningful clusters'. Hereafter, the characteristics of the clusters are determined using K-means clustering. A comprehensive explanation of used methods can be found in in section 0. Sub research question 2 is answered in section 5.2.

3.2.3 Sub research question 3: Which factors determine the intention to use ridesharing by Paleiskwartier students?

The third sub research question has relation with the micro level of the conceptual model. It is investigated which factors explain the intention to use ridesharing for *Paleiskwartier* students. Since the majority of *Paleiskwartier* students possess a free public transportation card (89%), the intention to use the full package of MaaS (including transit) is not investigated. It is assumed that students will not pay for transit (in a MaaS application), since they have a free public transportation card. Although a large share of the students possess a free public transportation card, the modal share of the private car is significant (13%). A reduction of the modal share of the car could be realized with ridesharing (i.e. higher occupancy rates of cars) and will be beneficial for the pressure on parking spaces and will reduce parking costs for students. Both aspects are the reason to investigate the potential of ridesharing among *Paleiskwartier* students. Data to answer sub research question 3 are gained with a digital survey, in which students are asked about the use of transit and private car, travel behavior in general, attitudes towards ridesharing and socio-economic characteristics. Based on literature on ridesharing (see 4.2.4), factors for the intention to offer *and/or* take a ride are asked to students. Based on the frequency of private car use, attitudes towards offering and/or taking a ride are asked. Ordinal logistic regression is used to estimate which factors determine the intention (i.e. probability) to use ridesharing, see section 4.3.3 for an explanation of this method. Sub research question 3 is answered in section 5.3.

3.2.4 Sub research question 4: What expectations do public and private actors have on the inclusion of societal goals in MaaS?

The fourth sub research question has relation with the meso level of the conceptual model. It has a focus on the inclusion of societal goals in MaaS, which also comprises steering on travel behavior with MaaS. The fourth sub research question is answered using semi-structured interviews with members of the ministry of Infrastructure and Waterworks, province Noord-Brabant, municipality 's-Hertogenbosch and two private MaaS integrators "A" and "B". Aspects that are captured during the interviews:

- Motivations to financially stimulate MaaS pilots
- Expectations of the province and municipality on the contribution of MaaS to their regional public transportation system (both from a policy and operational perspective)
- Attitudes towards steering on travel behavior (i.e. including societal goals) with MaaS

Semi-structured interviews and policy document analysis are conducted to answer sub research question 4, see section 4.4 for an elaboration on the interview questions. Interviews are held to reveal in-depth knowledge on how and why (not) the public transport authority aims at including societal goals in MaaS, also known as MaaS level-4 (see 2.2.3). Also, private MaaS integrators are asked about their attitude towards the inclusion of societal goals in MaaS and steering on travel behavior. Differences and similarities among public and private actors concerning attitudes towards MaaS level-4 are mentioned in section 5.4.

3.2.5 Sub research question 5: What opportunities and barriers are experienced by the MaaS integrator and public transportation authority regarding the organization of Mobility as a Service?

The fifth sub research question has relation with the meso level of the conceptual model. As research of Karlsson et al. (2017a) concludes, barriers are experienced with the organization of Mobility as a Service. Also, opportunities for vital collaborations are experienced by involved stakeholders in the process. Regarding the institutional organization of Mobility as a Service, institutional barriers arises, stated by Karlsson et al. (2017a): *'… a survey carried out within the MaaSiFiE project showed that stakeholders regard the lack of existing cooperation between for example public and private service providers as a potential barrier (König et al., 2016a; cf. also van der Audenhove et al., 2014) to the development of MaaS.'* (Karlsson et al. 2017a, pp. 7). This lack of operation could hinder a successful implementation of Mobility as a Service, taking the MaaS institutional framework into account. More specifically, regarding the interaction between the public transportation authority and the MaaS integrator: *'… a related obstacle is the perceived lack of appropriate business models. Although various models have been proposed in which different actors take on different roles (see e.g., König et al. 2016b), both private and public actors express uncertainty as to what their respective roles could, or should, be within a MaaS.'* (Karlsson et al., 2017a, pp. 8). Using semi-structured interviews with public and private stakeholders, the process of setting up MaaS in the case study area (see 3.3) is evaluated. The focus will be on the experienced commercial and technical barriers. Based on the experienced barriers, opportunities for (future) vital cooperation are asked to public and private actors as well. Results of the interviews will be linked to literature of Audenhove et al. (2014) and Meurs et al. (2018). Sub research question 5 is answered in section 5.5.

3.3 Case study area: *Paleiskwartier* Den Bosch

In this paragraph, the spatial configuration of the case study area is described. Also, the socio-economic characteristics and modal split of *Paleiskwartier* residents and students are mentioned.

3.3.1 Spatial characteristics

The neighborhood (the *'Paleiskwartier'*) is developed from the 1990s on, located in a former industrial area called *'Wolfsdonken'*. It is designed as a mixed land-use neighborhood, having education facilities (i.a. the University of applied sciences), offices, governmental institutions. The neighborhood is still in development, although the largest part is already developed. The *'Paleiskwartier'* has 3,130 residents, mostly persons between 25-45 years (45%) and a low share of children between 0-14 years (3.5%). The neighborhood is located in the city of Den Bosch (152,471 residents) and located in the semi-peripheral southern region of the Netherlands (the

Dutch metropolitan region Randstad is located 50 kilometres away) (de gemeente 's Hertogenbosch, 2018).

3.3.2 Socio-economic characteristics and modal split

In total, 1820 households are registered, mostly 1-person households (56%) or couples without children (38%). In total, 345 companies are registered in the '*Paleiskwartier*' (a mix of different types of companies, except agriculture and industry). In total, 1270 personal motorized vehicles are registered in the neighborhood, having 0.7 cars per household (in the Netherlands on average 1.1 cars per household). The neighborhood is characterized as a 'high urban environment' having 2743 addresses per km^2 (Centraal Bureau voor de Statistiek, 2017). Students in the *Paleiskwartier* (28.500 in total) mostly access the *'Paleiskwartier'* by public transportation (train, 47%, and BTM, 21%). An explanation for this is the existence of the free public transportation card for registered Dutch students (Kennisinstituut voor Mobiliteitsbeleid, 2014). The bike and car are used in similar extent, both contributing to 14 and 13% respectively of the modes used to access the *'Paleiskwartier'*. Regarding the use of shared cars, shared bikes and transit in a MaaS application, the existing modal split might influence the mode choice in a MaaS application.

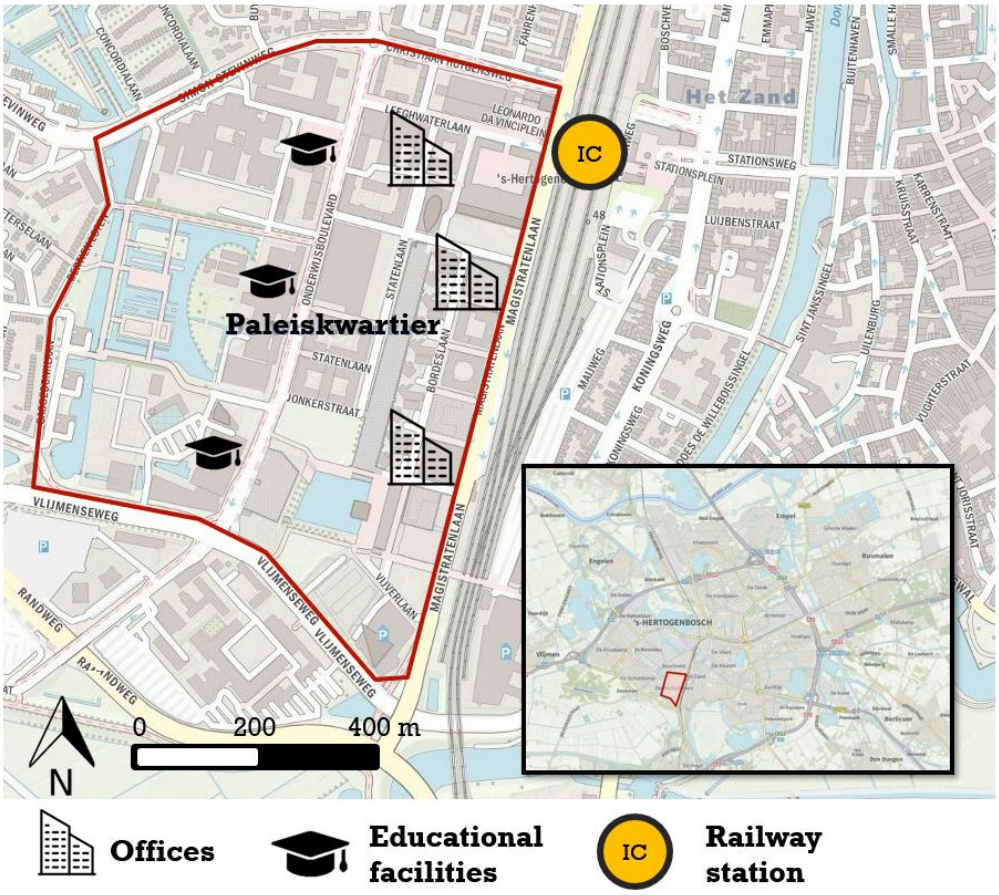


Figure 6 Location of the case study area (red line) in Den Bosch ('s-Hertogenbosch, Netherlands).

3.4 Stakeholders in MaaS *Paleiskwartier*

In this paragraph, involved stakeholders with the MaaS pilot in the *Paleiskwartier* are mentioned. In compliance with the institutional framework of Karlsson et al. (2017) and Sochor et al. (2015), three main groups of involved stakeholders are identified:
(1) those who use the mobility service
(2) those who organize the service
(3) those who are legally and spatially involved in the organization of that mobility service

3.4.1 Users of MaaS

The proposed users of the service are residents in the *'Paleiskwartier'* and students (using ridesharing within the MaaS application). It is expected that students would only use ridesharing, for reasons mentioned in 3.2.3.

3.4.2 Organization of MaaS

The integration of shared cars, shared bikes, ridesharing, taxi and public transportation is done by MaaS integrator "A". Also, the integrator is responsible for the operation and interface of the MaaS application, as well the payment method(s).

3.4.3 Responsible public organizations

The legal responsibility for the organization of public transportation is in the hands of the province of Noord-Brabant, according to Law on Public Transportation 2000. The municipality of 's-Hertogenbosch is involved since it provides the legal possibilities to reserve parking lots for shared cars (being part of the MaaS application).

3.5 Summary

The main research question of this research is: *'Which factors explain the intention to use Mobility as a Service and which barriers and opportunities are experienced with the organization of Mobility as a Service?'*. The main research question will be answered with five sub research questions, formulated in paragraphs 3.2.1 – 3.2.5. The main research question is related to a MaaS pilot in the case study area the *Paleiskwartier* (city 's-Hertogenbosch). The case study area is characterized by its high building densities, mixed-land use and closeness of an intercity railway station. The next chapter – 4.Methodology – elaborates on the used methods to answer sub research questions 1-5. Results for the sub research questions can be found in chapter *5. Results*. The main research question is answered in chapter *6. Conclusion and discussion*.

Chapter 4

Methodology

In this chapter the four used methodologies – surveys, semi-structured interviews, a focus group interview and policy document analyses – are explained.

▲ The Armada apartments alongside the central water basin.

4 Methodology

4.1 Used methodologies and relationship with research questions

Four methods are used in this research to answer the sub research questions (see 3.2.1 – 3.2.5): (1) surveys, (2) semi-structured interviews, (3) a focus group interview and (4) policy document analyses. The use of methods to answer sub research questions 1-5 is mentioned briefly in this paragraph and elaborated in paragraphs 4.2 – 4.6.

1. Surveys: (i) resident-survey to answer sub research questions 1 and 2 and (ii) student-survey to answer sub research question 3. The resident-survey is held on paper (door-to-door distribution) and digital. The student-survey is held digital. Data from both surveys are captured in separate datasets and processed with SPSS. An elaboration on the content of the resident-survey and student-survey can be found in paragraph 4.2. An elaboration on the use of statistical tests (i.e. Principal Component Analysis, ordinal logistic regression and K-means clustering) to answer sub research questions 1, 2 and 3 can be found in paragraph 4.3.

2. Semi-structured interviews: six interviews are held with private and public actors involved in the organization of MaaS in the *Paleiskwartier*. Semi-structured interviews are held to retrieve in-depth knowledge on the inclusion of societal goals in MaaS (sub research question 4) and evaluation of the process (sub research question 5). A predefined list of interview questions is used for each interview, but during the interview there is room to discuss topics that are not listed ex-ante. Interview questions are based on the topics related to sub research questions 4 and 5, retrieved from the literature (see 2.5). Interviews held lasted between 30 and 75 minutes and are all transcribed (see the Addendum). All transcriptions are coded and processed in tables to answer sub research questions 4 and 5 (see Appendix V.) Paragraph 4.4 elaborates on the content of the semi-structured interviews. Interview questions can be found in Appendix II.A. and II.B.

3. Focus group interview: an in-depth focus group interview with 15 'potential MaaS users'[4] is held to answer sub research question 1. Factors explaining the intention to use MaaS are retrieved from statistical tests, but in-depth motivations to have a (non) intention to use MaaS are gained with the focus group interview. The focus group interview is transcribed and coded (see the Addendum and Appendix IV.) to answer sub research question 1. See paragraph 4.6 for a detailed description of the content of the focus group interview.

4. Policy document analyses: the analysis of the policy document (i.a. the PTA's vision towards shared mobility) is used as input for the interview questions and for the reflection of answers to interview questions (see paragraph 4.6).

[4] Residents that indicated to be neutral or (very) likely to use Mobility as a Service in the *Paleiskwartier*.

4.2 Method 1: surveys

Distributing a survey is '*… particularly useful for eliciting people's attitudes and opinions about social, political and environmental issues … and also valuable for findings of complex behaviors.*' (Clifford et al., 2010, pp. 78). Regarding Mobility as a Service, surveys reveal information about travelers' attitudes, expectations and motivations to use Mobility as a Service, which is in line with the factors in the micro-level of the conceptual model (see 2.7). The target groups are *Paleiskwartier* residents and students. Data retrieved from the resident-survey are used to answer sub research questions 1 and 2. Data retrieved from the student-survey are used to answer sub research question 3.

4.2.1 Content of the survey

The survey has the following structure:

A. Current travel behavior	paragraph 4.2.2
B.1. Mobility as a Service for *residents*	paragraph 4.2.3
B.2. Ridesharing for *students*	paragraph 4.2.4
C. Personal characteristics	paragraph 4.2.5
D. E-mail address and information about MaaS	paragraph 4.2.6

4.2.2 A. Current travel behavior

The first part of the survey includes questions about the current travel behavior of respondents:

- Frequencies of usage of transport modes
- Mode preference for specific trip purposes
- Possession of a driving license and PT reduction card
- Important factors of choosing a specific mode
- Statements about the current infrastructure and accessibility of the neighbourhood
- Frequency of smartphone usage
- Mode possession in the household

Frequencies of use of transport modes is the main indicator for modal shift due to MaaS. As been indicated in the research of Sochor et al. (2015), MaaS could lead to a shift from car use to use of public transportation. Preferences for modes to reach specific destinations is of importance to reveal if due to the introduction of MaaS there is a change in mode preferences. The possession of a driving license and PT reduction cards are both proxies for the use of car and public transportation, respectively.

Important factors to choose a specific mode reveals to what degree travellers evaluate MaaS characteristics important (i.e. high importance of flexibility, low importance of travel time and a high importance of environment-friendly travel). Statements about the current infrastructure and accessibility in the neighbourhood are asked to indicate how positive the current accessibility by transit and car, parking possibilities and cycle infrastructure are evaluated by the residents. Changes in especially the parking possibilities are opted due to the introduction of Mobility as a Service: according to Sochor et al. (2015) MaaS could lead to a reduction of car possession (and a lowered need for parking space).

The frequency of use of trip planning smartphone applications (question six) is an indication to what extent residents are used to plan their trips via apps. Since the application of MaaS in the '*Paleiskwartier*' will be via a digital smartphone application, question six is a proxy how easy

travellers could adopt a new platform. The amount of travel modes in a household reveals the car possession rates per capita, which is an important predictor of the use of car sharing (see 2.6.2).

4.2.3 B.1. Mobility as a Service in the '*Paleiskwartier*'

In the middle part of the survey, an explanation of MaaS (textual and visual) is given, see Figure 7. The explanation of MaaS is done in a 'neutral' way, i.e. not mentioning any involved commercial organization, date of starting the service and specific costs for users. The core characteristics of MaaS are mentioned – the digital combination of different shared modes, transit and taxi – and three screenshots of the MaaS application are presented. Hereafter, the central question is asked to the respondents: '*If MaaS would be introduced, how likely is it that you will use MaaS?*' (answers on a 5-point Likert-scale, not very likely – very likely).

Explanation of Mobility as a Service in the resident-survey and student-survey.
"Soon a new mobility service will be introduced in the Paleiskwartier. This new service will allow you to access various forms of transport (such as car-sharing, bike-sharing, bus, train, and taxi) and you can ride with other residents of the Paleiskwartier. This will be done via a smartphone app, which will help you to make a good choice between different means of transport for every journey from A to B. You can then plan, book and travel within a single app. Besides, you can choose between paying per ride or having a monthly subscription."

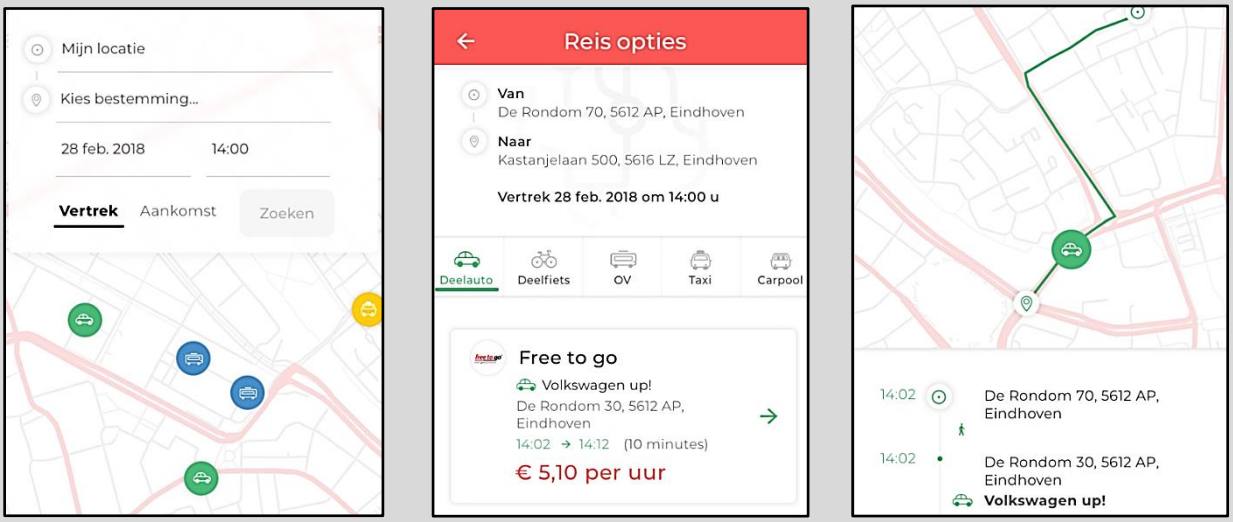


Figure 7 Explanation of Mobility as a Service in the resident-survey and student-survey.

The central question is followed by 8 statements on aspects specifically related to the characteristics of MaaS[5]. These statements are used to indicate to what extent there is a relationship between the intention to use MaaS and (a selection of) statements, see Table 1 for an overview.

[5] N.B. it is not mentioned to respondents that these statements are directly related to MaaS.

Statement	Contribution of MaaS
S1. "I do not mind having a longer travel time, as long as the trip is less expensive."	MaaS could provide cheaper, but longer trips
S2. "I Think that it is important to drive less by car, because of environmental concerns"	MaaS could reduce car possession, thereby contributing to the shift to sustainable mobility
S3. "I do not need to possess a car, if travel alternatives would be (almost) everywhere and anytime available."	MaaS offers an easy (interpretable) access to a wide range of travel alternatives
S4. "New mobility concepts (e.g. Uber or BlaBla car) make me enthusiastic."	MaaS is part of a new mobility concept
S5. "My own car gives me a lot of freedom."	If MaaS is used when persons do not possess a car any more, personal freedom could be harmed
S6. "I am sometimes looking for travel alternatives for my own car."	MaaS could offer transport possibilities for persons that are willing to sell their (second) private car.
S7. "My mobility pattern varies on a weekly basis."	MaaS fits to differing travel patterns (different travel origins and destination over time and space)
S8. "I do not mind travelling with unknown persons."	Part of MaaS is ridesharing and transit, in which persons travel together with unknown persons

Table 1 MaaS related statements.

4.2.4 B.2. Ridesharing for students

Factors explaining the use of ridesharing are mentioned in paragraph 2.6.3. Convenience, reliability and shorter travel times (compared to transit) contribute to the intention to use ridesharing. Compared to car driving, the avoidance of drunk driving and the absence of parking stress are mentioned as factors that explain the intention to use ridesharing (Kennisinstituut voor Mobiliteitsbeleid, 2018). An important aspect of ridesharing is the pick-up and drop-off locations of the student. For students willing to take a ride, it is of relevance to investigate to how important they evaluate the closeness of the pick-up/drop-off location to their origin and destination. For students willing to offer a ride, it is of relevance to investigate to what degree they are willing to take a detour to pick up passengers. Students are also asked how early they would prefer an acknowledgement of ridesharing and to what level they are satisfied with the price[6] asked/given for a taken/offered ride (Deakin, et al., 2011) (Tezcan, 2016).

Based on frequencies of mode use, students are asked about their likeliness of either taking or offering a ride. Frequent transit users and frequent car passengers – equal or more than 3 days/week using these modes – are asked about their intention to *take* a ride. Hereafter, attitudes towards ridesharing specific statements are asked, see Table 2.

[6] For this research, a price of 0.125 euro/km is used to calculate a price for ridesharing for a specific travel distance from home to school, based on the price asked by MaaS integrator "A".

"I would use ridesharing …
S1: *… to avoid the hassle of looking for a parking spot."*
S2: *… to reduce costs for the possession and operation of my car."*
S3: *… to meet new people."*
S4: *… to positively contribute to the environment."*
S5: *… to increase my travel time from home to school."*

Table 2 Ridesharing related statements.

Also, attitudes towards aspects related to taking a ride are asked, see Table 3. The level of satisfaction of the price for taking a ride – based on the home-to-school distance – is asked.

"If I would take a ride …
DP1: *… I want to have a guaranteed back- and forth trip."*
DP2: *… I want to have a guaranteed trip more than 1 day ex-ante."*
DP3: *… I want to be dropped off (very) close to school."*
DP4: *… I want to know with whom I will travel."*

Table 3 Ride-taking statements (demand-specific).

Frequent car drivers – equal or more than 3 days a week car driving – received similar questions to frequent transit users/car passengers, but additionally were asked about their intention to *offer* a ride (rather than solely taking). Additionally, attitudes towards aspects related to offer a ride were asked to frequent car drivers, see Table 4.

"I would easier offer a ride …
SP1: *… when I have information about the ride sharing person."*
SP2: *… when I get a money for offering the ride."*
SP3: *… when I receive credits or awards, to be changed for presents."*
SP4: *… when I receive a discount on parking costs."*
SP5: *… when I participate in a contest (the winner receives a price) ."*

Table 4 Ride-offering statements (supply-specific).

4.2.5 C. Personal characteristics

Socio-economic variables that are asked in the survey include:

- Postal code (6 digit): to indicate in which exact block the respondent lives
- Gender
- Age
- Household size
- Annual household income
- Education level
- Participation (working, retirement etc.)[7]

These socio-economic variables are asked for two reasons. First, these variables could be used to explain the characteristics of a cluster from cluster analysis, i.e. 'demographic profiling' and thereby answering sub research question 2 (Okazaki, 2006). Demographic profiling is *'…the process of splitting the market by considering personal similarities and differences, such as*

[7] Excluded for the student-survey

gender, age, marital status, occupation, monthly allowance, and household structure. Such descriptive attributes have been used in most industry surveys.' (Okazaki, 2006, pp. 129).

Second, socio-economic variables could be used to apply weighting. This technique is used to correct for skewness in the distribution of the survey population with respect to the neighborhood population, e.g. to correct for an overrepresentation of elderly in the survey, compared to the age distribution in the neighborhood (Statistics Canada, 2003). The socio-economic variables in the conducted survey are in a similar manner to the variables asked in the UbiGo trial in Göthenborg (Karlsson et al., 2016). Education level and PC6 are additional variables in the conducted survey, to indicate whether education level is related to interest in MaaS and to indicate residential location.

4.2.6 D. E-mail address

Respondents' e-mail addresses are asked – with their personal permission – to provide them a reward for filling in the survey and to provide them with additional information on Mobility as a Service. According to the Dutch Law on Protection of Personal Data (*Algemene Verordening Gegevensbescherming, AVG*) all data are used for this specific research, all data are safely stored and only accessible by the researchers.

4.2.7 Sample size

Regarding the size of the population in the *'Paleiskwartier'*, 3130 persons (year: 2018), a sample size of at least 331 persons is needed (95% confidence level, margin of error +/- 4%). The sample size of that is needed for the student population is 379 (95% confidence level, margin of error +/- 4%). based on a total population of 28,500 (Avans, 2019; HAS Hogeschool, 2019).

4.2.8 Distribution of the survey

The resident-survey is distributed both digital (platform Qualtrics) and house-to-house distributed in post boxes. In total 1870 surveys were printed and distributed to 1870 households in the *Paleiskwartier*. Each household received a printed survey, explanatory letter and a QR code and link to the digital survey. The student-survey was available via the digital platform Qualtrics. Response rates of the student-survey are increased by personal advertising by the author. This personal advertisement comprise the distribution of printed flyers for two universities in the neighborhood (executed four times in total).

4.3 Processing the data from the surveys

Answers to the questions of the ex-ante survey will be processed using the workflow depicted in Figure 8. Essentially, the process comprises three steps:

1. Inspective	general pattern of answers, missing values and sample composition
2. Explorative	relationship independent variables and intention to use MaaS
3. Explanatory	traveller segmentation and factors that explain the intention to use MaaS

After inspecting descriptive statistics, the Chi-square test and measure of association Kendall's tau-b will be used to explore which independent variables have an influence on the *intended* use of MaaS (i.e. question 9: *'If MaaS would be introduced, how likely is it that you will use MaaS?'* Principal Component Analysis (PCA) is used to create a set of uncorrelated components,

thereby reducing the original number of variables in the dataset. This creates a less complex dataset. After creating the first component, Varimax extraction is used to define the next component, until the Eigenvalue is below the threshold of 1.0. Each next component is created orthogonally in vector space compared to the previous component (i.e. Varimax extraction methodology). The Varimax methodology has a clear interpretation and is most common to use in SPSS. Only independent variables having communalities higher than 0.4 are included to create components (Wold, et al., 1987).

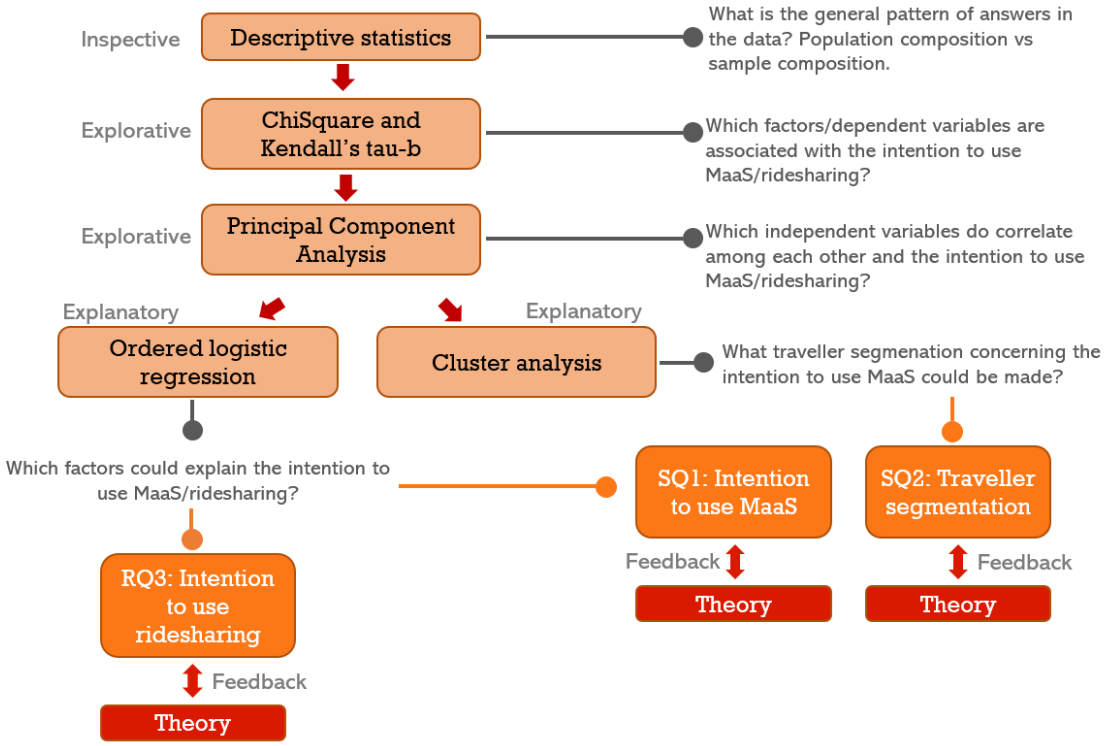


Figure 8 Processing data from surveys: workflow.

An important note for the use of PCA: results of PCA are used intuitively, which means that results of PCA reveal which independent variables have an association with the interest in MaaS/ridesharing. All associated variables revealed from PCA are put into the ordinal logistic model and clustering procedure, not the principal components. This, to reveal which distinct independent variables contribute significantly to clusters and the interest in MaaS, rather than which component contributes to the cluster/interest in MaaS.

4.3.1 Cluster analysis

Cluster analysis is used for traveler segmentation concerning the intention to use MaaS, i.e. answering sub research question 2. The central purpose of cluster analysis is dividing a large set of data into distinct sub groups (segmenations of travellers), thereby maximizing similarity amount the travel charactersitics within the cluster and at the same time maximizing the differences between clusters (Michailiadou, et al., 2009). Input for the cluster analysis will be the independent variables that correlate among each other, resulting from Principal Component Analysis.

Important for cluster analysis is the distance measure between the centroids of the clusters. The Mahalanobis distance is used for this analysis: *'... the Mahalanobis distance is based on the*

Pearson correlation coefficient which is computed between the observations of two cases or subjects. This correlation coefficient is used to cluster the cases.' (Verma, 2013, pp. 321). Ex-ante the clustering procedure, each single case is considered to be a single cluster and distances between these clusters are calculated using the Mahalanobis distance. This results in a proximity matrix, in which several cases are linked together, and distances are calculated again, using amalgamation criteria.

For this research, hierarchical agglomerative clustering is used to estimate the number of clusters (derived from the dendrogram). This method creates *'... a hierarchy of clusters which may be represented in a treelike structure known as dendrogram. Objects are grouped into a tree of clusters by using the distance (similarity) matrix as clustering criteria. In this tree structure, the root consists of a single cluster containing all observations, whereas the leaves refer to the individual observations.'* (Verma, 2013, pp. 323).

Non-hierarchical clustering (K-means) is used after hierarchical agglomerative clustering. The number of clusters ("K") is derived from the dendrogram in Appendix III.D. The first step in K-means clustering is finding K-centres and a classification of all cases regarding their distance to these K-centres. Thereafter, cases are assigned to these K-centres, thereby forming clusters. This procedure continues iteratively, until the cluster means do not differ significantly. Optimizing portioning is the approach - cases are assigned to a specific cluster based on an optimization algorithm – that is used in non-hierarchical clustering. Conclusions of cluster analysis are in paragraph 5.2.

4.3.2 Logistic regression

Logistic regression is used to estimate the probability (odds ratio) of the dependent variable 'Intention to use MaaS'. This is to estimate the intention to use MaaS or ridesharing, answering sub research question 1 and 3, respectively. The dependent variable 'Intention to use MaaS' is measured on a 5-point Likert scale, ordinal logistic regression is used to investigate which independent variables could explain the interest in using MaaS. Ordinal logistic regression captures the 'nature of the ordinal, dependent variable' and contains most valid responses of the original (Fullerton, 2009).

An important part of a logistic regression model in SPSS is the Log-likelihood of the model (i.e. the degree to which the binary logistic model explains the variance of the dependent variable). A significantly *reduced* Log-likelihood (-2LL) implies that the model explains *more* of the variance of the dependent variable when including the independent variables. The log-likelihood is *' -2 times the natural log of the opportunityal probability of each group multiplied by the number of individuals in each group'* (Osborne, 2017, pp. 5). The log-likelihood is affected by the opportunityal probabilities of each group and the number of respondents per group (the latter indicates that larger sample sizes have larger log-likelihoods).

Nagelkerke's R^2 is a pseudo r-squares measure of linear regression – the summary of the proportion of variance of the dependent variables that is related with the independent variable(s) – corrected between 0 and 1. Nagelkerke's R^2 is based on Cox and Snell's R^2, in which the log likelihood between the baseline and (final) model are compared (Osborne, 2017). The omnibus test for Chi square is used to indicate whether the logistic model is significantly better (i.e. having lower log-likelihood or have a higher R^2) than the baseline model. Important

prerequisites are that independent variables uncorrelated (Pearson's correlation coefficient "r" should be smaller than 0.8) to avoid multicollinearity and that observations are independent (e.g. not sampling homogenous groups) (Osborne, 2017).

4.3.3 Ordinal logistic regression

The cumulative approach for ordinal logistic regression is used to answer the sub research question 1 and 3. For this approach, the dependent variable 'Intention to use MaaS', having *'M'* answer categories, will be split into *'M-1'* logit equations (Fullerton, 2009). For this research, the dependent variable is transformed to a 3-point Likert scale, since the 'outskirts' of the answer categories of the dependent variable have low shares of respondents. The proportional odds model is used, in which the following equation describes the log odds (Fullerton, 2009):

$$\log\left(\frac{PR(y \leq m|\boldsymbol{x})}{PR(y > m|\boldsymbol{x})}\right) = \tau_m - x\beta \ (1 \leq m < M) \qquad \text{(Equation 1).}$$

In this equation, *m* is an answer category, **x** is a vector of independent variables, τ is a cut point and β is a vector of logit coefficients. Regarding the interpretation of the β's: *'… a negative sign of the logit coefficients (β) is similar to the interpretation of linear regression: a unit increase in 'x' leads to a lower level of 'y' (the dependent variable).'* (Fullerton, 2009, pp. 312). The proportional odds assumption is one of the most essential prerequisites for ordinal logistic regression, which is *'the assumption of equal β's across logit equations for different cut points'* (Fullerton, 2009, pp. 312). The assumption of proportional odds is tested with the ex-post 'test of parallel lines', which has to be significant ($p < 0.05$). Other statistical test characteristics – e.g. Nagelkerke's R^2 – are similar interpretable to binary logistic regression. Ordinal logistic regression in SPSS will provide parameter estimates, but those are not directly interpretable. A transformation table, in which the cumulative proportions are calculated, provides an interpretable result, per independent variable separately. The cumulative proportion will be used to calculate the cumulative probability, using the formula:

$$Cumulative\ proportion = \frac{1}{(1+e^{B})} \text{ with } B = parameter\ estimate \qquad \text{(Equation 2).}$$

Results of ordinal logistic regression can be found in paragraph 5.1.3.3 (sub research question 1) and 5.3.4 (sub research question 3).

4.4 Method 2: semi-structured interviews

This method is used to answer sub research questions 4 and 5. A semi-structured interview is *'… a verbal interchange where one person, the interviewer, attempts to elicit information from another person by asking questions.'* (Clifford et al., 2010, pp. 103). Different from full-structured interviews, the role of the researcher (the 'interviewer') is less dominant: *'…although the interviewer prepares a list of predetermined questions, semi-structured interviews unfold in a conversational manner offering participants the chance to explore issues they feel important.'* An important aspect is the selection of participants: *'… usually, people are chosen based on their experience related to the research topic.'* (Clifford et al., pp. 108). Therefore, the interviewees from public and private organizations all are (in)directly involved in the MaaS pilot in the *Paleiskwartier* or have experience with MaaS. The goal of semi-structured interviews is *'…not to be representative (a common mistake or criticism to this technique) but to understand how*

individual people experience a situation.' (Clifford et al, pp. 109). Therefore, results presented in paragraphs 5.4 and 5.5 should be interpreted carefully and not extrapolated without thought. The contents of the semi-structured interviews is slightly different for interviewees from public and private organizations. Paragraph 4.4.1 describes the content of interviews for public organization interviewees. Paragraph 4.4.2 describes the content of interviews for private organization interviewees.

4.4.1 Interview topics for public organizations

All interview questions for the Ministry of Infrastructure and Waterworks, public transport authority (province) and municipality can be found in Appendix II.A. The following topics are discussed during the interviews:

- Goal and definition of Mobility as a Service
- Inclusion of MaaS in transport and spatial policies
- Differences and similarities in public-private values and objectives regarding MaaS
- Contractual agreements regarding MaaS pilots
- Innovations in transit and the role of SMEs, start-ups and conventional transit organizations
- Operational aspects of MaaS (e.g. technical harmonization, attracting users etc.)
- Change in travel behavior and different steering mechanisms for change

The relevance of discussing the topics describe above is as follows. A clear definition setting is of importance for the process of implementing Mobility as a Service (Sochor, et al., 2017a). The inclusion of MaaS in transport and spatial policies is of importance from developments towards MaaS level-4 (Sochor et al., 2017a) and to answer sub question 3. Differences in public and private values and objectives are of relevance to answer sub question 4 and could be compared to research of Meurs et al. (2018). Contractual agreements, innovations and operational aspects are of importance to evaluate barriers and motivations to cooperate in a so called 'MaaS ecosystem', from the governmental perspective (Smith, et al., 2017b). Behavioral steering is discussed from the perspective of MaaS level-4 (steering on behavior according to specific policy goals).

4.4.2 Interview topics for private actors (MaaS integrators)

Interview questions of different MaaS integrators can be found in Appendix IIb. The following topics are discussed during the interviews:

- Goal and definition of Mobility as a Service
- Involvement of MaaS integrators in different MaaS pilots
- Technical, commercial and organizational barriers during the setting-up and operational phase
- Change in travel behavior and different steering mechanisms for change
- Collaboration between all stakeholders in the MaaS pilot

The relevance of discussing these topics is as follows. A clear definition setting is of importance for the process of implementing Mobility as a Service (Sochor, et al., 2017a). Differences in the definition of MaaS between private and public actors could be revealed when asked the goal and definition of MaaS. Involvement of the MaaS integrators in specific MaaS pilots is asked to gain background knowledge of their (technical) contributions. Technical, commercial and organizational barriers – from the perspective of the MaaS integrator – are asked to compare to the situation of the pilot in the *Paleiskwartier* to another MaaS pilot. Empirical information

retrieved from the interviews is compared to scientific conclusions regarding barriers and motivations in the process of setting up MaaS (i.a. Meurs et al. (2018) and Smith et al. (2018a)). Behavioral steering is discussed from the perspective of MaaS level-4 (steering on behavior according to specific policy goals), but with a focus on how MaaS integrators evaluate behavioral steering.

4.5 Processing data from interviews

Data from the semi-structured is recorded, after the permission of the interviewee. Recorded interviews are transcribed (in Dutch) and analyzed with the use of 'coding' (Weston, et al., 2001). The following codes are used for the semi-structured interviews with professionals:

1. MaaS in practice: experiences with MaaS (pilots) and relevant research
2. Goal and definition of MaaS: definition MaaS, sustainability, potential MaaS users and factors explaining the intention to use MaaS
3. Position of MaaS in the mobility ecosystem: relationship with traditional public transport and spatial and transport policies, future implications of MaaS for transit/car use.
4. Cooperation stakeholders: public-private cooperation, technical barriers, goals, visions and economical aspects

These codes are based on the literature review – see 2.1, 2.3, 2.4 and 2.5. These four code categories will be used to extract key characteristics of the interview transcripts, thereby providing answers to sub research questions 4 and 5. Conclusions of the interviews are in paragraph 5.4 and 5.5.

4.6 Method 3: a focus group interview

The third method – a focus group interview – is used to answer sub research question 1. From a scientific perspective, a focus group is *'… a semi structured group session, moderated by a group leader, held in an informal setting, with the purpose of collecting information on a designated topic'* (Carey, 1994, pp. 190). The reasons to conduct a focus group interview regarding the central question are threefold (McLaffert, 2004):

- The user (or consumer) is seen as the 'expert', rather than professionals: regarding the central question, end-users are eventually *using* the service and could evaluate its possibilities and barriers for using from the costumer perspective the best.
- Dynamic interaction during the focus group leads to more in-depth information than retrieved from the survey. An important side note is that this in-depth information is often not representative, but complementary to information from surveys.
- Insight in attitudes and opinions: regarding the theorem presented in chapter 2 this is of importance to enrich the answers for sub research questions 1.

4.6.1 Which persons are invited for the focus group?

All residents having a neutral of (very) likely intention to use MaaS (N=162) are asked to participate in a focus group interview. In total, 29 residents were willing to participate in the focus group, of which 15 were eventually were invited. All of these invited participants are 'neutral' or '(very) likely' to use MaaS. The reason to select solely interested persons for this focus group is as follows: to reveal the deeper motivations to (potentially) use MaaS in the future. Disinterested persons are not invited for a focus group, since it would cost more time and effort to do research on all motivations *not* to use MaaS, rather than motivations to use

MaaS. It is important to note that potential MaaS users (i.e. the participants of the focus group) are not solely asked about their perceived benefits, but also their perceived disadvantages of MaaS.

4.6.2 Composition of the focus group

The composition of the focus group is comparable to the composition of the residents in the *Paleiskwartier*. Homogeneity of the group is mentioned as an important prerequisite of a focus group session (Carey, 1994). For this research, homogeneity is reached regarding the interest in MaaS (all participants have a somehow positive attitude towards the use of MaaS). However, homogeneity is not reached regarding age and gender, but is chosen to represent the composition of the *Paleiskwartier* population.

4.6.3 Organization of the focus group

Having an interview guideline is an important prerequisite for a structured focus group session. However, the interview questions should not restrict participants in their answer possibilities (McLafferty, 2004). Therefore, open-ended questions are asked and participants will be given enough room for their opinions and thoughts. The role of the moderator – which is the author of this master thesis – could be described as follows: *'… to create a non-threatening supportive climate that encourages all participants to share views; facilitating interaction among members; interjecting probing comments, transitional questions and summaries without interfering too brusquely with the dialogue; covering important topics and questions while relying on judgements to abandon aspects of the outline, noting non-verbal responses.'* (McLaffert, 2004, pp. 190). Concerning the data collection, audiovisual recording (having two media recorders) will be used to capture the conversations during the focus group session (Carey, 1994). The outline of the focus group session has been:

- Welcome with coffee/tea 15 min
- Getting to know each other 15 min
- Current travel behavior 25 min
- Short break 15 min
- Explanation Mobility as a Service 10 min
- Discussion about use of MaaS 20-25 min
- Conclusion 10 min

The total duration of the focus group is estimated for two hours, including the welcome drinks, break and concluding part. An important facet of the focus group session are the first two blocks, in which the participants should feel 'welcome' (McLafferty, 2004). If participants feel that they are 'not seen' in this first block, then they might feel excluded from the group. The block 'current travel behavior' is used to investigate which modalities are often used by participants to travel from and to the *Paleiskwartier* and which travel patterns are most common. MaaS characteristic elements are discussed regarding their choices in modalities and travel patterns, such as flexibility, use of transit, environmentally friendly travel, travelling with unknown persons, use of ICT/smartphone and travel planning applications. A short break is induced after 45 minutes, to let the participants relax a little bit. After the break, Mobility as a Service is explained to the participants, with a visualization of the MaaS app and a short movie (2 minutes) of the province Noord-Brabant about MaaS. Hereafter, the participants and moderator discuss their potential use of Mobility as a Service.

4.7 Processing data from the focus group interview

The focus group is recorded with an audiovisual camera, to capture as much as possible conversations and body languages. All conversations are transcribed, see the Addendum. In similar manner to the semi-structured interviews, transcriptions are coded and processed in overview tables. The following codes are used, in compliance with factors determining the interest in MaaS based on research of Karlsson et al. (2017a) and *Kennisinstituut voor Mobiliteitsbeleid* (2018):

1. **Easiness**: MaaS is expected to increase the ease of planning trips
2. **Costs (savings):** MaaS is expected to potentially save costs (e.g. no possession of a car)
3. **Flexibility:** MaaS is expected to contribute to flexible travel patterns
4. **Accessibility**: MaaS is expected to increase accessibility for persons not owning a car
5. **Dependence**: MaaS requires trust and dependence of the user on the system
6. **Data:** MaaS generates a new combinations of flows of traveler data

Citations are used to reify these six factors. Opinions of the focus group participants will be reflected using the research of Karlsson et al. (2017a) and *Kennisinstituut voor Mobiliteitsbeleid* (2018). See paragraph 5.1.4 for conclusions of the focus group interview.

4.8 Method 4: analysis of policy documents

Policy documents of the province of Noord-Brabant and the municipality of Den Bosch could work as the basis for the semi-structured interviews. The province of Noord-Brabant has *'the legal responsibility for public buses. Regarding train traffic, the province has agreements with the Ministry of Infrastructure and Water Work and the Dutch Railways.'* (de Provincie Noord-Brabant, 2018). The municipality of Den Bosch is responsible for the spatial infrastructure, i.a. the parking lots for the shared cars being part of the MaaS application. The analysis of policy documents has two main objectives: (1) to locate the positionality of MaaS policies in existing spatial and mobility policies of the province and municipality and (2) to reveal role positions of the province and municipality regarding the collaboration between the MaaS integrator and public authority. Results of the analysis of policy documents will be used as input for the semi-structured interviews, meaning that the policy documents will be analyzed before the semi-structured interview will be held.

4.9 Summary

To answer sub research questions 1 till 5, four methods are used: (1) surveys, (2) semi-structured interviews, (3) a focus group interview and (4) policy document analyses. Sub research question 1 is answered using PCA/ordinal logistic regression on data from the resident-survey, see 5.1.3 for results. Deeper motivations for the intention to use MaaS are retrieved from the focus group interview, see 5.1.4 for results. Sub research question 2 is answered using clustering analysis on data from the resident-survey, see 5.2 for results. Sub research question 3 is answered using PCA/ordinal logistic regression on data from the student-survey, see 5.3.4 for results. Sub research questions 4 and 5 are answered with semi-structured interviews and policy document analyses, see results in 5.4 and 5.5, respectively.

The next chapter – 5. Results – contains all results for sub research questions 1 till 5. Results are discussed in chapter 6.

Chapter 5

Results

Results for each sub research question are presented in this chapter. A mix of methods is used to answer the sub research questions.

▲ Mixed land-use in the *Paleiskwartier*. The ground floor holds restaurants, the building has residential accommodations on the front and offices on the back of the building.

5 Results

This chapter contains results for sub research questions 1- 5 (formulated in paragraph 3.2). For sub research question 1, factors explaining the intention to use MaaS by *Paleiskwartier* residents are mentioned in paragraph 5.1. For sub research question 2, traveller segmentation – concerning the intention to use MaaS – is presented for *Paleiskwartier* residents in paragraph 5.2. Factors explaining the intention to use ridesharing by *Paleiskwartier* students – sub research question 3 – are mentioned in paragraph 5.3. Concerning sub research question 4, the expectations of involved private and public actors on the inclusion of societal goals are presented in paragraph 5.4. Results for sub research question 5, i.e. experienced barriers and preferred opportunities during the process of setting up MaaS, are mentioned in paragraph 5.5.

5.1 Sub research question 1: Which factors determine the intention to use Mobility as a Service by Paleiskwartier residents?

This section describes the factors that explain the intention to use Mobility as a Service by *Paleiskwartier* residents. First, the composition of the sample is compared to the composition of the neighborhood population, the population of 's-Hertogenbosch and residents of densely populated areas in the Netherlands. Univariate, bivariate and multivariate statistics are used to reveal which factors determine the intention to use MaaS.

5.1.1 Univariate statistics: composition of the sample

It is concluded that the sample[8] (N =556) is significantly different from the population, see Table 5. Differences exist for age and household composition (i.e. an over representation of elderly and an under representation of one-person household in the sample). For other socio-economic variables, either there is no significant difference between the sample-population (cf. gender), or there is no data available for the population (cf. income or education level). Chi-square tests indicate that there is no significant difference when weighting is applied for both age and household composition. For household size, the Chi-square value slightly improves after weighting, but remains insignificant (χ^2 5.13 versus χ^2 5.57, p = 0.23, df = 4.). For age, weighting neither provides an improvement of the relationship (χ^2 = 6.98 versus χ^2 = 7.10, p = 0.31, df = 6). Therefore, it is concluded that weighting in unnecessary, taking the dependent variable 'Intention to use MaaS' (Q9) into account.

5.1.1.1 The *Paleiskwartier* sample compared to the city 's-Hertogenbosch

Using data from '*Onderzoek Verplaatsingen in Nederland (OViN)*[9]', travel behavior characteristics of the *Paleiskwartier* residents are compared to the citizens in 's-Hertogenbosch and to residents of densely populated areas in the Netherlands (i.e. living in the same spatial configuration as *Paleiskwartier* residents). It is concluded that the share of (very) frequent use of transit is higher for *Paleiskwartier* than other citizens in 's-Hertogenbosch (χ^2 = 277.506 (df = 4), p < 0.000). Regarding (private) car possession, it is concluded that *Paleiskwartier* residents

[8] For this research, the number of cases of resident-survey used for statistical analyses is 556 (November 2018). The complete resident survey dataset contains 568 cases (January 2019). No significant differences exist among both datasets, concerning results of statistical tests and conclusions.

[9] Data combined for the years 2012-2015.

significantly have lower car possession rates per household *($\bar{x}$ = 0.93 cars/household)* than the population of 's-Hertogenbosch *($\bar{x}$ = 1.34 cars/household)* (t = -12.575, p<0.000).

		Sample		**Population *Paleiskwartier****	
		N	%	N	%
Gender	male	309	55,1%	1645	52,6%
	female	252	44,9%	1480	47,4%
Age	0-14 yr**	0	0,0%	115	3,7%
	15-24 yr	30	5,5%	440	14,1%
	25-44 yr	221	40,5%	1440	46,0%
	45-64 yr	138	25,3%	615	19,6%
	65+ yr	157	28,8%	520	16,6%
Household size	1 person	210	37,4%	1155	55,8%
	2 persons	315	56,0%	795	38,4%
	3+ persons	37	6,6%	125	6,0%
Education level	Low	24	4,3%	N/A	
	Medium	104	18,5%	N/A	
	High	433	77,2%	N/A	
Yearly gross income	<€12,500	16	2,9%	N/A	
	€12,500 - €26,200	36	6,4%	N/A	
	€26,201 – €38,800	91	16,2%	N/A	
	€38,801– €65,000	182	32,4%	N/A	
	€65,001 – €77,500	82	14,6%	N/A	
	>€77,500	114	20,3%	N/A	
	unknown	40	7,1%	N/A	

*Table 5 Sample characteristics versus population characteristics. * source: CBS (2017) **Not included in the statistical analyses.*

5.1.1.2 The *Paleiskwartier* sample compared residents of densely populated areas

Concerning the household composition, it is concluded that households in the *Paleiskwartier* are significantly smaller ($\bar{x}$=1.69) than the average household in 's-Hertogenbosch ($\bar{x}$=3.13, t = -25.881(df=3427), p<0.000). Regarding the societal participation, it is concluded that retirees are overrepresented and employees are underrepresented in the *Paleiskwartier* sample, compared to residents of densely populated areas in the Netherlands, see Table 6.

Residents of densely populated areas in the Netherlands*				***Paleiskwartier* sample**			
Working**	Jobless	Student	Retired	Working**	Jobless	Student	Retired
49.2%	**15.2%**	**17.4%**	**18.2%**	**64.1%**	**3.0%**	**3.4%**	**29.5%**

*Table 6 Societal participation of residents of densely populated areas in the Netherlands versus Paleiskwartier residents. *citizens living in high urban areas in the Netherlands (CBS stedelijksgraad 1). ** including employees and freelance workers.*

It is concluded that *Paleiskwartier* residents more often prefer to use the train, but less often prefer to use the car for different trip purposes, compared residents of densely populated areas in the Netherlands (see Table 7). Concerning the frequencies of mode use (Table 8), it is

concluded that *Paleiskwartier* residents use the train on a more frequent basis than average for residents of densely populated areas in the Netherlands. On the other hand, the car and slow modes are used less frequent by *Paleiskwartier* residents.

	Residents of densely populated areas in the Netherlands			***Paleiskwartier* sample**		
Preferred modes for trip purposes	**Train (%)**	**Car (%)**	**Slow modes (%)**	**Train (%)**	**Car (%)**	**Slow modes (%)**
From/to work	3.6	50.5	39.7	25.4	38.2	34.0
Business trip	14.1	76.6	7.2	40.9	53.4	3.9
School	8.8	41.9	39.7	28.0	19.2	51.3
Shopping	2.7	48.4	40.1	3.6	9.8	85.2
Visit	1.6	61.5	33.2	10.7	52.6	35.3
Going out	13.1	79.9	13.5	43.9	52.3	3.1

Table 7 Differences in preferred mode use for different trip motives (Netherlands based on MPN (2015) N = 1297. Data for the Paleiskwartier based on the resident-survey (N = 556).

	Residents of densely populated areas in the Netherlands			***Paleiskwartier* sample**		
Frequency of mode use	**Train (%)**	**Car (%)**	**Slow modes (%)**	**Train (%)**	**Car (%)**	**Slow modes (%)**
Daily	7.3	36.6	48.1	16.9	16.4	27.2
Weekly	11.6	29.2	21.4	14.7	28.0	32.8
Monthly	18.4	18.0	10.6	24.1	23.9	18.2
Sometimes	13.9	8.3	4.5	38.6	17.0	9.9
(Almost) never	48.6	8.0	15.4	5.8	14.7	11.8

Table 8 Differences in frequencies of mode use among high urban Dutch persons (N = 640) and Paleiskwartier residents (N = 556). For the use of the car, the average is taken for frequencies of being a car driver and passenger.

5.1.1.3 Note on representativeness

Results of this survey are representative for the *Paleiskwartier* neighborhood, but *not* for the population of the city 's-Hertogenbosch, due to large differences in both the composition of the population as the travel behavior. Results of this survey are also not representative in comparison with other high-density urban environments in the Netherlands, based on societal participation – the *Paleiskwartier* sample contains more retired persons (29.5% vs. 13.9%), but less students (3.4% vs. 13.4%). Preferred mode use and frequencies of mode use are also different. Therefore, conclusions drawn on the intention to use MaaS by *Paleiskwartier* residents could not be extrapolated for other high urban neighborhoods in the Netherlands nor the city of 's-Hertogenbosch.

5.1.1.4 General travel behavior of *Paleiskwartier* residents

Concerning mode use from and to the *Paleiskwartier*, it is concluded that walking, cycling and driving a car without passengers are the most frequent used modalities. For the use of the car, three different categories could be distinguished: (1) car driver with no passengers, (2) car

driver with passengers and (3) car passenger. Most frequent car trips concern car driving without passengers (which contribute to 70% on a regular basis). Almost a third of the residents use the train on a regular basis (weekly or daily) and buses are used more infrequent than trains. Walking and cycling are also very frequent used modalities.

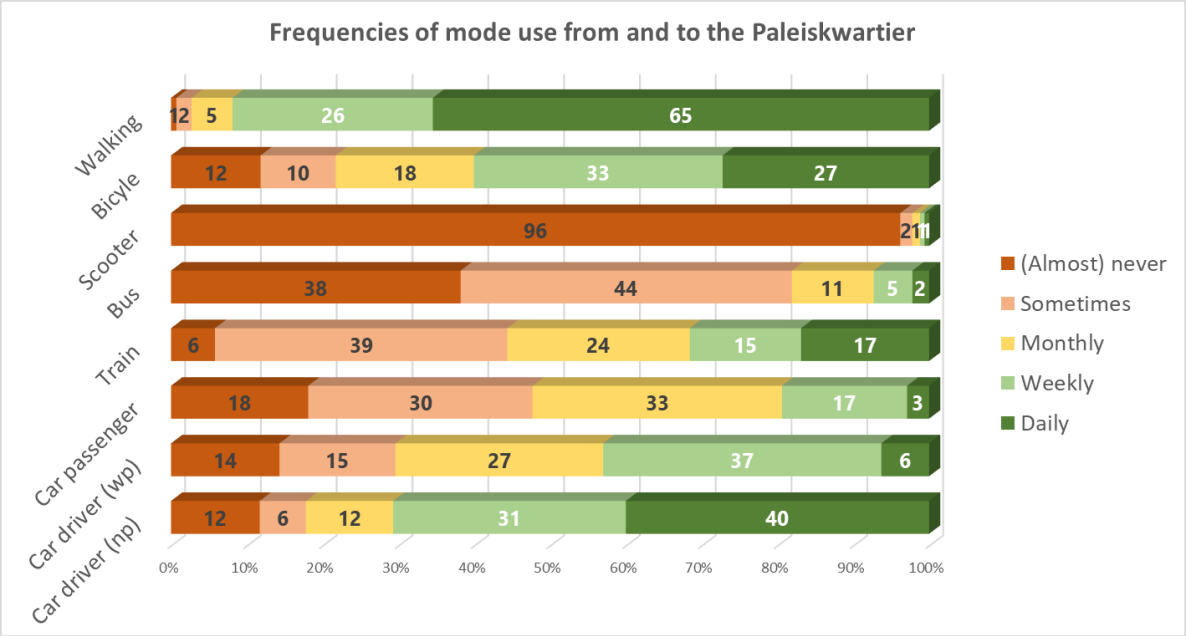


Figure 9 Frequencies of mode use (per person, based on the amount of trips)

5.1.1.5 Travel aspects

Regarding aspects related to a mode choice, the importance of six travel aspects concerning the modal choice is evaluated. It is concluded that travel aspect A:3 ('Comfort') is evaluated as the most important. Also, A:4 ('A short travel time') and A:6 ('Flexibility) are evaluated as (very) important by a large share of the respondents. Flexibility is related to Mobility as a Service, since one of the key characteristics of MaaS is multimodality and interconnectivity between modalities, which requires a more flexible attitude of users than conventional car use (Karlsson et al., 2017). Environment is concerned as the least important travel aspect.

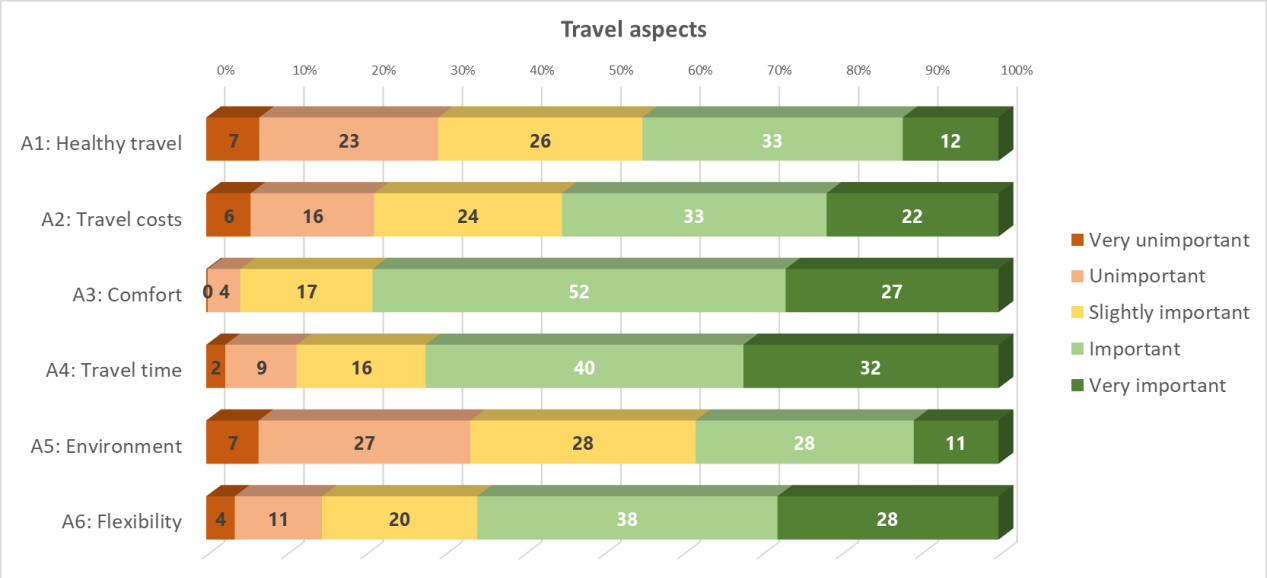


Figure 10 Travel aspects

5.1.1.6 Intention to use MaaS

The central question of the survey – Q9: '*If MaaS would be introduced, how likely is it that you will use MaaS?*' – is answered quite negatively. More than half of the respondents (55%) indicate that it is (very) unlikely that they would use MaaS. 20% of the respondents indicate that it is (very) likely that they would use MaaS when the service will be operational.

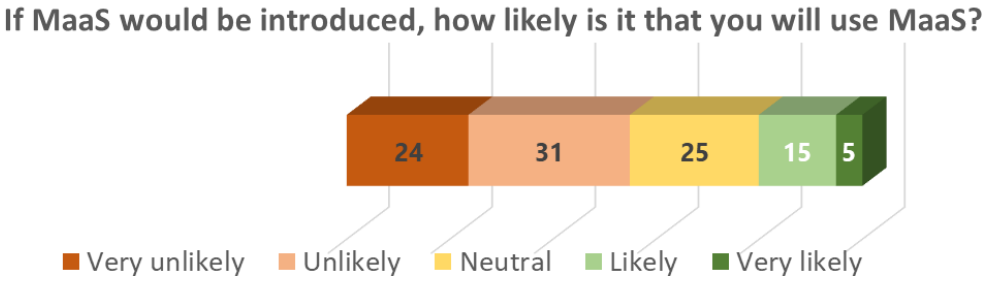


Figure 11 Interest in using MaaS (percentages)

5.1.1.7 MaaS related statements

Concerning the statements related to Mobility as a Service (see paragraph 4.2.3) it is concluded that respondents mostly agree with S:5 ('I think the car gives me a lot of freedom'), S:2 ('I would like to travel less by car, for environmental concerns'), S:7('My travel patterns varies over time') and S:6 ('I am sometimes looking for travel alternatives for my own car'). Respondents highly disagree with S:8 ('I like to travel with unknown persons') and S:3 ('I do not need to possess a car, if travel alternatives would be (almost) everywhere and anytime available.').

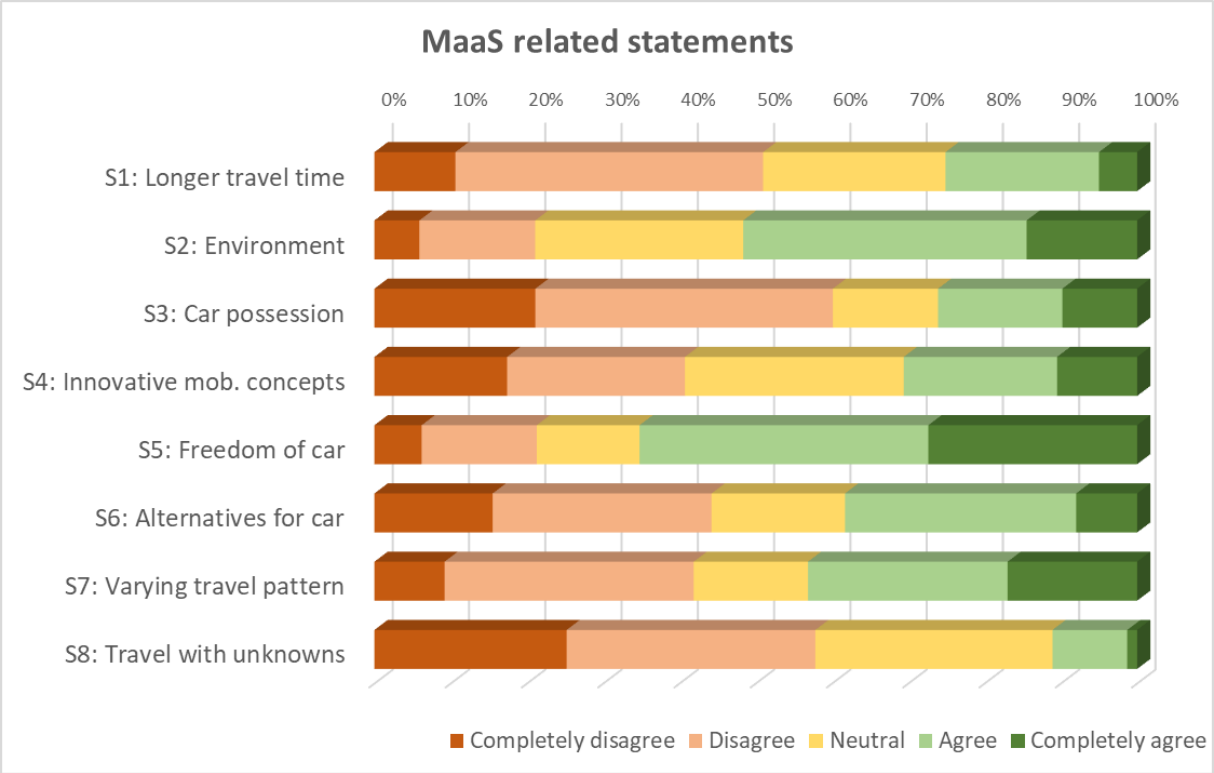


Figure 12 MaaS related statements.

5.1.2 Bivariate statistics: association with interest in MaaS

Bivariate statistics are used to indicate the association between independent variables and the dependent variable 'intention to use MaaS'. The following associations are derived:

- Socio-economic variable 'education level' is significantly associated with the intention to use MaaS, see paragraph 5.1.2.1.
- 3 out of 6 travel aspects are significantly associated with the intention to use MaaS, see paragraph 5.1.2.2.
- 6 out of 8 statements on MaaS are significantly associated with the intention to use MaaS, see paragraph 5.1.2.3.

5.1.2.1 Socio-economic variables and the intention to use MaaS

It is concluded that socio-economic variable 'education level' is associated with the intention to use MaaS. This conclusion is interestingly, since it is not in line with conclusions from other MaaS pilots, in which socio-economic variables do explain the intention to use MaaS. For example, for the UbiGo trial in Göthenborg, households with children were looking for travel alternatives (e.g. Mobility as a Service) for their private car (Sochor et al., 2015); Karlsson et al., 2017). Concerning age, younger persons tend to be more interested in MaaS than older generations, as is concluded from the SMILE pilot in Vienna (Karlsson et al., 2017). The lack of association between socio-economic independent variables and the intention to use MaaS should be interpreted with some prudence, since the sample is not well representing the composition of the population of the *Paleiskwartier* (see paragraph 5.1.1.1).

Association	X^2	p-value
MaaS and gender	4.32 (df = 2)	0.115
MaaS and age*	6.98 (df =6)	0.323
MaaS and education level	11.60 (df =4)	0.021
MaaS and household size	5.13 (df = 4)	0.274
MaaS and income level	10.40 (df = 10)	0.407

Table 9 Chi-square test for socio-economic variables. (*) age categories 0-24 yr / 25-44 yr / 45-64 yr / 65+ yr. In line with MPN and CBS.

5.1.2.2 Travel aspects and the intention to use MaaS

Regarding the association among travel aspects and intention to use MaaS, it is concluded that A:1 'Healthy travel', A:5 'Environmentally friendly travel' and A:6 'Flexible travel' are significantly associated with the intention to use MaaS. Kendall's tau-b indicates a moderate positive association, the higher the evaluation of A:1 and A:5, the higher the interest in Mobility as a Service.

Association	X^2	p-value	Kendall's tau-b
A1: MaaS and healthy travel	46.82 (df = 8)	< 0.00	0.25*
A2: MaaS and travel costs	10.86 (df = 8)	0.210	-
A3: MaaS and comfort	8.55 (df = 8)	0.382	-
A4: MaaS and travel time	4.20 (df =8)	0.839	-
A5: MaaS and environment	33.82 (df =8)	< 0.00	0.21*
A6: MaaS and flexible travel	17.03 (df = 8)	0.03	*insignificant*

*Table 10 Association between the six travel aspects and interest in using MaaS. Note that kendall's tau-b is not calculated for insignificant associations. * p < 0.05.*

5.1.2.3 MaaS statements and the intention to use MaaS

Respondents that are (highly) agree with MaaS statements 1, 2, 3, 4, 6 and 8 are more intended to use MaaS than respondents that (highly) disagree with these statements, see Table 11. Frequent car users are less intended to use MaaS, contradict to frequent train and bus users. Statements 5 and 7 are insignificantly associated with the intention to use MaaS.

Variables	χ^2 value (df)	Kendall's tau-b
S1. "I do not mind having a longer travel time, as long as the trip is less expensive."	27.8* (df = 8)	0.19**
S2. "I Think that it is important to drive less by car, because of environmental concerns"	57.2** (df = 8)	0.29**
S3. "I do not need to possess a car, if travel alternatives would be (almost) everywhere and anytime available."	99.1** (df = 8)	0.35**
S4. "New mobility concepts (e.g. Uber or BlaBla car) make me enthusiastic."	81.1** (df = 8)	0.35**
S5. "My own car gives me a lot of freedom."	4.45 (df = 4)	N/A
S6. "I am sometimes looking for travel alternatives for my own car."	58.7** (df = 8)	0.28**
S7. "My mobility pattern varies on a weekly basis."	4.48 (df = 4)	N/A
S8. "I do not mind travelling with unknown persons."	45.7** (df = 4)	0.31**
Frequency of car use	20.1* (df = 6)	-0.16**
Frequency of train use	15.9* (df = 6)	0.13**
Frequency of bus use	21.6* (df = 6)	0.17**

*Table 11 Chi square values of all relevant variables that significantly differ from the null hypothesis. * $p < 0.05$, ** $p < 0.00$. For statement 6 the answer categories are merged to meet the demands of the Chi-square test (minimum expected count >1 and max. 20% of the cells having an expected count less than 5).*

Note that the associations presented in 5.1.2 are explorative, not explanatory. This means that the combination of variables is not taken into account in this statistical step, which is in the next paragraph on multivariate statistics.

5.1.3 Multivariate statistics: explanatory factors for the interest in MaaS

The first sub question is answered using Principal Component Analysis (PCA, see paragraphs 5.1.3.1-2) and ordinal logistic regression (see paragraphs 5.1.3.3-4).

5.1.3.1 Results of factor analysis (PCA)

Factor analysis has been conducted for all assumed significant variables, which are travel aspects (Q4), statements (Q10) and frequency of mode use (Q1) and socio-economic variables (Q12-14-15-16). The dependent variable 'intention to use MaaS' (Q9) is included. In total, seven components were created, using the Varimax method with coefficients larger than 0.35. See Table 12 for detailed information. Component 1 contains all independent variables correlated with the dependent variable 'intention to use MaaS', see the next paragraph for a detailed explanation.

5.1.3.2 The component 'intention to use MaaS' (component 1)

Taking the first component into account, the following scores on independent variables could explain the intention to use Mobility as a Service:

- People that evaluate healthy and environmentally friendly travel aspects as important
- People agreeing with 'MaaS statements', except statement *'varying travel behavior'* (insignificant) and statement *'freedom of car'* (negative score)
- Frequent users of train/bus and cyclists
- Infrequent users of the private car

In line with results of bivariate statistics (see paragraph 5.1.2), no socio-economic variables are correlated with the intention to use MaaS.

	Components						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Travel aspects							
Aspect - healthy travel*	0,61			-0,43			
Aspect - travel costs		0,39				0,41	
Aspect – comfort		0,60					
Aspect – travel time		0,68					
Aspect – environment	0,63			-0,47			
Aspect – flexibility		0,60					0,39
Statements							
Statement – longer travel time*	0,40		-0,38			0,48	
Statement – environment	0,72						
Statement – car possession	0,69						
Statement – interest innovations	0,38	0,37			0,38		
Statement – freedom of car	-0,37		-0,38				
Statement – alternatives car	0,45						
Statement – varying travel pattern						-0,35	0,57
Statement – unknown persons	0,51						
Mode use							
Frequency car use**	-0,53	0,43					
Frequency train use**	0,40		0,46		-0,40		
Frequency bus use**	0,39				-0,40		
Frequency cycling**	0,45						
Socio-economic							
Education level			0,50				
Household size			0,45			0,45	
Household income			0,60				
Gender						-0,50	-0,49
Intended MaaS use (Q9)	0,62						

Table 12 Factor Analysis (PCA), using Varimax method with coefficients larger than 0.35. (*) Likert scale (1-5), excluding 'no answer' and 'no opinion'. (**) distributed into five categories [(almost) never – sometimes – monthly – weekly – daily).

5.1.3.3 Ordinal logistic regression

Results of both the Principal Component Analysis and bivariate analysis provide input for the ordinal logistic regression. An important prerequisite for regression analysis is the absence of multicollinearity among independent variables. This requirement could be checked by calculating the correlation matrix among the independent variable listed below. As is concluded from Appendix III.B, there are no significant large correlations ($r>0.8$, $p<0.05$) among independent variables, thereby excluding the issue of multicollinearity. The following set of independent variables is used for the ordinal logistic model:

- Education level
- Travel aspect 1: Healthy travel
- Travel aspect 6: Flexibility
- Statement 1: Longer travel time
- Statement 2: Environment
- Statement 3: Car possession
- Statement 4: Interest in new mobility concepts
- Statement 6: Alternatives for the car
- Statement 8: Travel with unknown persons
- Frequency of car use

The frequencies of use of transit and cycling are excluded, since the model turned out to be insignificant when these independent variables were added to the model.

Ordinal logistic regression proves that six independent variables could significantly explain the dependent variable 'Intention to use MaaS' (Q9), which are:

- Travel aspect 1: healthy travelling
- Travel aspect 6: flexible travelling
- Statement 3 – 'I do not need to possess a car, if travel alternatives would be (almost) everywhere and anytime available.'
- Statement 4 – 'New mobility concepts (e.g. BlaBla car or Uber) make me enthusiastic'
- Statement 6 – 'I do sometimes look for alternatives for my own car'
- Statement 8 – 'I do not mind travelling with unknown persons'

The initial log likelihood is 773.144 and the final log likelihood of the model is 596.868. Nagelkerke's R^2 is 0.41 which is notable high. See Table 14 for an overview of model parameters. No significant interaction effects have been found among the independent variables. The test of parallel lines is insignificant ($\chi^2 = 5.176$ (8), $p = 0.739$) indicating that the slope parameters are not similar across response categories and therefore is in compliance with the prerequisites of ordinal logistic regression. See Table 14 on page 65 for the ordered logit model characteristics.

5.1.3.4 Cumulative probabilities

For all significant β's ($p < 0.05$), cumulative probabilities are calculated, see Table 13. Cumulative probabilities are calculated with respect to the baseline category, which is the highest score on the independent variable (which is 'totally agree', 'very important' or 'high'). Cumulative probabilities are presented for three levels of likeliness of using MaaS: (very) likely, neutral and (very) unlikely. The overall pattern is that the higher a respondent scores on the independent variable, the more one is likely to use MaaS. However, for travel aspect 'flexible

travel', this assumption does not hold according to the ordinal logistic model. Since the β's are positive, it holds that the higher a respondent scores on the independent variable, the lower the probability of being (very) likely to use MaaS. That the importance of flexible travelling and likeliness of MaaS are inversely related compared to other significant independent variables is somewhat discrepant from the perceived flexibility that MaaS could offer. For example, the pilot of UbiGo and SMILE in Vienna revealed that MaaS could offer a solution for flexible travel demand, e.g. families who are looking for additional travel possibilities for their privately-owned car (Karlsson et al., 2017). Also, for other car sharing schemes, a flexible and multimodal travel pattern characterizes these car sharing members (Kopp, et al., 2015). An explanation for the positive β's for travel aspect 'flexible travel' could be that frequent car users evaluate the flexibility of the car as important, or that the question is unclear formulated for the respondent.

	Q9: Intention to use MaaS		
	(very) unlikely	**neutral**	**(very) likely**
S3: Car possession ([totally] disagree)	9%	27%	64%
S3: Car possession ([totally] agree)	4%	14%	82%
S4: Innovations ([totally] disagree)	19%	38%	43%
S4: Innovations (neutral)	9%	27%	65%
S4: Innovations ([totally] agree)	4%	14%	82%
S6: Alternatives for car ([totally] disagree)	9%	28%	63%
S6: Alternatives for car ([totally] agree)	4%	14%	82%
S8: Travel with unknown persons ([totally] disagree)	12%	31%	57%
S8: Travel with unknown persons ([totally] agree)	4%	14%	82%
A1: Healthy travel (unimportant)	13%	33%	54%
A1: Healthy travel (neutral)	10%	29%	60%
A1: Healthy travel (very important)	4%	14%	82%
A6: Flexible travel (neutral)	1%	6%	93%
A6: Flexible travel (important)	2%	9%	89%
A6: Flexible travel (very important)	4%	14%	82%

Table 13 Cumulative probabilities for significant independent variables.

As is concluded from Table 13 and Table 14, scoring on the independent 'S4: Innovations' mostly explains the probability of being (un)likely to use MaaS. Persons having a negative view on 'S4: Innovations' ('*New mobility concepts (e.g. BlaBla car or Uber) make me enthusiastic*') have a probability of 43% to be a MaaS user, compared an 82% probability for persons having a positive view on this statement. This indicates that intrinsic interest in new mobility concepts is an important explanatory factor for the likeliness of using MaaS. This result is in line with Karlsson et al. (2017): the SMILE pilot in Vienna indicates that a large group of technology interested young adults are interested in using Mobility as a Service. These 'early adaptors' use MaaS because they are intrinsically motivated to test and use new technologies (Karsslon, et al., 2017). The evaluation of healthy travelling is also an important explanatory variable, taking the β-values and cumulative probabilities into account.

Ordinal logistic model – resident survey	**Estimate**	**Std. Error**	**Wald**	**df**	**Sig.**	**95% Confidence Interval**	
Variable						**Lower Bound**	**Upper Bound**
Interest in using of MaaS ([very] unlikely)	**-3,260***	,590	30,517	1	,000	-4,416	-2,103
Interest in using of MaaS (neutral)	**-1,519***	,567	7,181	1	,007	-2,631	-,408
Interest in using of MaaS ([very] likely)	0	.	.	0	.	.	.
S1: Longer travel time ([totally] disagree)	-,197	,291	,461	1	,497	-,767	,372
S1: Longer travel time (neutral)	-,033	,321	,010	1	,919	-,662	,597
S1: Longer travel time ([totally] agree)	0	.	.	0	.	.	.
S2: Environment ([totally] disagree)	-,354	,340	1,083	1	,298	-1,020	,313
S2: Environment (neutral)	-,037	,298	,015	1	,902	-,620	,547
S2: Environment ([totally] agree)	0	.	.	0	.	.	.
S3: Car possession ([totally] disagree)	**-,931***	,287	10,535	1	,001	-1,492	-,369
S3: Car possession (neutral)	-,486	,370	1,722	1	,189	-1,212	,240
S3: Car possession ([totally] agree)	0	.	.	0	.	.	.
S4: Innovations ([totally] disagree)	**-1,802***	,292	38,183	1	,000	-2,374	-1,231
S4: Innovations (neutral)	**-,917***	,283	10,460	1	,001	-1,472	-,361
S4: Innovations ([totally] agree)	0	.	.	0	.	.	.
S6: Alternatives for car ([totally] disagree)	**-,978***	,263	13,803	1	,000	-1,493	-,462
S6: Alternatives for car (neutral)	-,464	,324	2,051	1	,152	-1,099	,171
S6: Alternatives for car ([totally] agree)	0	.	.	0	.	.	.
S8: Travel with unknown persons ([totally] disagree)	**-1,228***	,383	10,288	1	,001	-1,979	-,478
S8: Travel with unknown persons (neutral)	-,551	,399	1,911	1	,167	-1,332	,230
S8: Travel with unknown persons ([totally] agree)	0	.	.	0	.	.	.
A1: Healthy travel (very unimportant)	-,854	,632	1,824	1	,177	-2,093	,385
A1: Healthy travel (unimportant)	**-1,344***	,467	8,304	1	,004	-2,259	-,430
A1: Healthy travel (neutral)	**-1,096***	,444	6,094	1	,014	-1,966	-,226
A1: Healthy travel (important)	-,507	,411	1,523	1	,217	-1,313	,299
A1: Healthy travel (very important)	0	.	.	0	.	.	.
A6: Flexible travel (very unimportant)	,929	,668	1,933	1	,164	-,380	2,238
A6: Flexible travel (unimportant)	,119	,438	,074	1	,786	-,740	,978
A6: Flexible travel (neutral)	**1,046***	,348	9,018	1	,003	,363	1,729
A6: Flexible travel (important)	**,598***	,285	4,387	1	,036	,038	1,157
A6: Flexible travel (very important)	0	.	.	0	.	.	.
Education level (low)	,089	,718	,015	1	,901	-1,317	1,496
Education level (medium)	,523	,312	2,823	1	,093	-,087	1,134
Education level (high)	0	.	.	0	.	.	.
Car use ([almost] never)	,843	,490	2,966	1	,085	-,116	1,803
Car use (monthly)	,097	,339	,082	1	,775	-,567	,761
Car use (weekly)	-,146	,271	,291	1	,590	-,678	,386
Car use (daily)	0	.	.	0	.	.	.

*Table 14 Model characteristics of the ordinal logistic model. * p < 0.05*

5.1.4 Focus group among MaaS interested residents

A focus group was held with 15 residents of the *Paleiskwartier*. A selection of interested residents is made based on the composition of the neighbourhood (regarding age and gender). For privacy reasons, names of participants are not available. It is important to note that all participants indicated that they are 'neutral' or '(very) likely' to use MaaS, when it is available in the near future.

Figure 13 Participants of the focus group interview (9 January 2019) and the moderator (author of this research). (Own figure, 2019).

5.1.4.1 Composition of the focus group participants versus sample

An important note is that information derived from a focus group interview is not representative for the whole population due to differences in the composition (Carey, 1994). The focus group used for this research is comparative (N.B. *not* representative) to the *Paleiskwartier* sample concerning age (average and standard deviation), societal participation, income levels, car possession and possession of a PT card, see Appendix III.G. No significant difference or similarity among the focus group and sample could be proved, due to the small size of the focus group (N = 15). Travel aspects are evaluated in an *approximate* similar manner by the focus group and sample, except for healthy travel. However, the focus group is not comparative regarding gender (higher share of females in the focus group compared to the sample, 71.4% and 44.4% respectively). Also, concerning preferred travel modes, participants of the focus group prefer in a higher extent the train or bike for commuting, business trips and going out, compared to the sample. Focus group participants are positive towards innovative mobility concepts, are looking for alternatives for their private car and do not evaluate car possession as very important when travel alternatives are widely available. Note that all focus group participants filled in the survey ex-ante the focus group conversation.

5.1.4.2 Contemporary travel behavior

Participants were asked about their existing travel behavior, aspects to the choice of modalities and the use of travel planning applications.

Car possession:

- 6 out of 15 participants do not have a car in the household. Non-car participants indicate that they manage their trips to destinations with transit (predominantly the train from intercity station 's-Hertogenbosch) or with the bike. Additionally, for destinations difficult to reach by transit, non-car owners often use shared cars (Greenwheels) to manage the trips.
- 9 out of 15 participants do have at least one car in the households, most often used for non-work related trips (visiting family and friends), since work-related trips are predominantly done by bike or train

Use of travel planning applications and interest in new apps:

- Most participants travelling with transit on a daily basis indicate that they mostly use travel planning application (e.g. NS Extra) to check whether trains are running, or not. It is concluded that the usage of travel planning applications is predominantly to check the 'guarantee of mobility'.
- Participants indicate that they do not really favour to test new apps randomly, but they are willing to try out new forms of travel planning applications. This indicates that when potential MaaS user will be attracted for a MaaS app, the added value of the MaaS app should be explained explicitly ex-ante.
- Older participants indicate that they do not favour to use new apps, since they use their smartphone not very frequent. This is in line with research of Karlsson et al. (2017), which indicates that younger generations tend to easier use new mobility applications.

Factors determining the modal choice:

- Almost all participants think that reliability and travel time are the most important to reach the destination. Since MaaS is characterized by chain-mobility, system reliability is an important aspect that should be taken into account for potential MaaS users.

5.1.4.3 Attitudes towards Mobility as a Service

Before asking the attitudes of participants towards MaaS, the concept of Mobility as a Service is explained to participants using a 2-minute movie. See Figure 14.

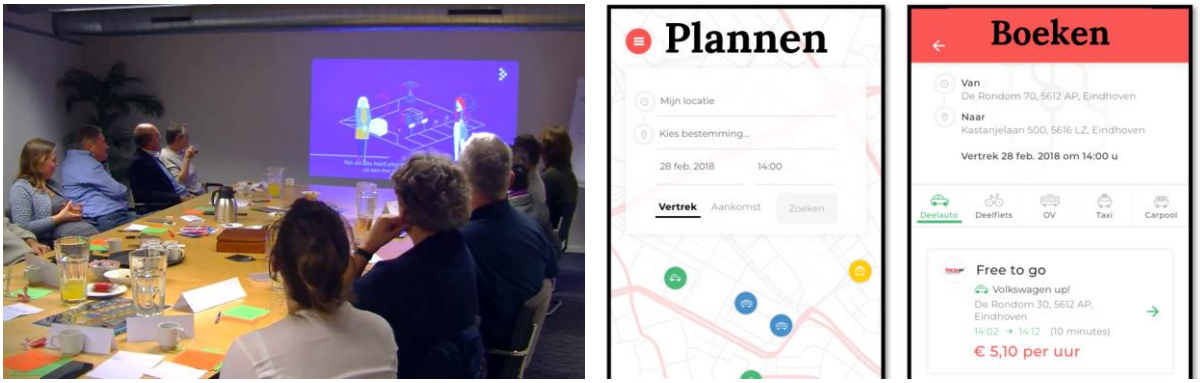


Figure 14 (Left) MaaS ecosystem movie that is shown to participants (retrieved from the Provincie Noord-Brabant. (Right) illustration of a MaaS application that is presented to participants.

The province Noord-Brabant (the public transport authority) has provided a short movie of 'the vision on a future MaaS ecosystem in Noord-Brabant'. In this video, the definition of MaaS is presented and an illustration of the future MaaS ecosystem is given. This, to familiarize the participants with the position of MaaS in the larger mobility network (De provincie Noord-Brabant, 2019). Hereafter, a specific MaaS application is shown, to indicate what is possible with Mobility as a Service, concerning daily travel motives. It is explicitly mentioned to participants that the pilot will be held in the *Paleiskwartier*, but that MaaS will be eventually available on a larger scale.

5.1.4.4 Added value of Mobility as a Service

Participants were critically regarding the added value of MaaS compared to the travel possibilities of the Dutch Railways (NS). The NS provides also shared bikes and shared cars, in combination with train services, offered in a digital application NS Extra. As one participant indicates (female, 28 years) about the added value of the MaaS application:

'What is the added value of this application? I can already book my Greenwheels [shared car provided by NS] to reach my destination. I do not see any added value of this service…'

Female, 28 years

The added value of MaaS – compared to the use of shared modes separately – is also an important prerequisite for the level-of-use, concluded by the *Kennisinstituut voor Mobiliteitsbeleid* (2018). Research (i.a. Karlsson et al. (2017a)) indicates that the integration of different modes in one smartphone application could '*promote the use of more sustainable transportation modes, such as transit*' (*Kennisinstituut voor Mobiliteitsbeleid*, 2018, pp. 4). However, participants indicate that they use transit already to a very high extent, since the intercity railway station is within 1 km distance from almost all residential properties. The private car, being an unsustainable mode, is solely used to reach destinations that are inaccessible by car. After mentioning the benefits of MaaS – e.g. a higher level of convenience, more freedom of mode choice, and potentially cheaper and shorter journeys (cf. KiM (2018)) – participants still do not evaluate the added value of MaaS, compared to the wide range of shared modes (e.g. Greenwheels and OV-fiets) and transit (rail and bus) that are now available. Tailored-made travel advices that are provided by a MaaS integrator is not evaluated as very positive by the participants. They have distrust in a (commercial) MaaS integrator:

'I do not want that a commercial organization traces all my movements. And what about financial margins? I mean, such a travel application company has to make profit on it, and they somewhere have to receive the money from. So, I will be paying more than when I rent all shared modes separately…'

Female, 48 years

Concerning the use of ICT for MaaS, it is concluded that the 'digital divide' does not hold for the participants. The lack of skills to use ICT could hinder potential MaaS user from using the service (*Kennisinstituut voor Mobiliteitsbeleid*, 2018). Almost all participants are familiar with using a smartphone travel applications, such as *NS Extra* or *9292ov.nl*.

5.1.4.5 Habitual behavior of frequent private car users

Easiness to use, guaranteed availability and perceived costs of shared modes are the most mentioned prerequisites that determine the level-of-use of Mobility as a Service. Especially participants that do not (frequently) use shared cars, emphasize that perceived hourly costs refuse them to use shared cars. Also, the easiness of their own private car (easy to access, always available) is mentioned as an important factor not to use shared cars. Also, the effort to plan (habitual) trips on a daily basis is mentioned as an important barrier:

'Using MaaS, I have to use a travel planner on a daily basis. I think that would costs a lot of time and effort, since I have to look every day again which travel mode I have to take to reach my job. My private car gives me ease and is always available'

Male, 26 years

The guaranteed availability of shared modes is mentioned as an important factor by participants. This is in line with results from the focus group discussion held by the *Kennisinstituut voor Mobiliteitsbeleid* (2018) in which *'…shared mobility modes introduce new meanings of reliability, which differ from the usual meaning of reliability in conventional public transport, because of the uncertainties about local availability that are inherent to the flexible and finite (scarce) nature of such services.'* (pp. 25). Availability of shared modes is highly linked to choice freedom, which is mentioned as an important factor determining the interest in using MaaS from the UbiGo trial in Göthenborg (Sochor et al., 2015).

5.1.4.6 Coverage of MaaS and non-transit accessible destinations

During the discussion, participants emphasize the coverage of MaaS as an important factor. Apart from the perspective that MaaS could smoothen the trip from A to B from an individual perspective, MaaS could also enhance equity in accessibility (*Kennisinstituut voor Mobiliteitsbeleid*, 2018). For example, Mobility as a Service could improve the accessibility of areas that are inaccessible by transit (e.g. rural villages or industrial areas), which could benefit specific societal groups that do not have access to a private car but need transportation to reach their destination (Martens, 2018). Participants emphasize that they are predominantly interested to use MaaS to reach their destinations that are currently inaccessible by transit, which is in line with literature on *demand-responsive transport (DRT)*, that is predominantly used in non-urban areas (Davison, et al., 2012). As one participant emphasizes:

'I think it is a nice idea, this new mobility service, but I would only use it when I can reach my family in the rural areas surrounding this city. For trips within the city, I use my bike or I take the train to reach other cities.'

Female, 52 years

This last citation is in line with literature on the use of DRT within cities: the presence of an intercity railway stations reduces the probability of using demand-responsive transport for destinations accessible by transit (Davison et al., 2012). For destinations inaccessible by transit, participants are interested in using shared cars or ridesharing. Participants prefer to share cars on a non-commercial, small scale basis, to avoid additional costs of an intervening commercial MaaS integrator.

5.1.5 Answer to sub research question 1

The *Paleiskwartier* sample is different from the population of 's-Hertogenbosch and from residents of densely populated areas in the Netherlands, concerning socio-economic characteristics and preferred mode use (i.e. an over representation of retirees and a very high preference for using the train for different trip purposes). Therefore, the answer to sub research question 1 is only valid for *Paleiskwartier* residents and could not be extrapolated. It is concluded that positive attitudes towards MaaS specific characteristics – i.e. the MaaS statements 1-4, 6 an 8 – and the evaluation of healthy travelling explain the intention to use MaaS by Paleiskwartier residents. No socio-economic variables do explain the intention to use MaaS. 20% of the residents indicate that it is (very) likely that they will use MaaS, 25% is neutral towards their intention and 55% is (very) unlikely to use MaaS. Of those residents that are neutral or (very) likely to use MaaS, fifteen focus group participants emphasize that MaaS does not have a (direct) added value for them, compared to the available shared modes (e.g. Greenwheels, OV-fiets) and train station in the neighbourhood. Also, the preference for using the private car (i.e. flexibility) and the area of coverage of MaaS are important barriers for the intention to use MaaS, as indicated by the focus group participants. However, 6 out of 15 focus group participants do not have a car in the household and do use transit on a regular basis, which are important proxies for the intention to use MaaS (Karlsson et al., 2016; Kennisinstituut voor Mobiliteitsbeleid, 2018). The next paragraph – the answer to sub research question 2 – will go into detail about the characteristics of potential MaaS users (derived from traveller segmentation).

5.2 Sub research question 2: What traveler segmentation is of relevance concerning the intention to use Mobility as a Service?

This paragraph describes what traveller segmentation of relevance concerning the intention to use MaaS. Distinct traveller groups – based on the intention to use MaaS – could be extracted from the homogenous group of residents in the *Paleiskwartier*, which is depicted as 'traveller segmentation'. As described in paragraph 4.3.1, hierarchical and K-means cluster analysis are conducted. The input variables of cluster analysis are based on the associated variables with interest in MaaS, resulting from Principal Component Analysis (see paragraph 5.1.3.1). The dendrogram resulting from hierarchical clustering is depicted in Appendix III.D and reveals 4 distinct clusters. Hereafter, K-means clustering ($k = 4$) is conducted to reveal which independent variables characterize specific cluster members. The following four clusters are distinguished and explained in the next paragraphs:

- Cluster 1: Potential MaaS users (N = 66) [18.4%]
- Cluster 2: Frequent car drivers (N = 85) [23.8%]
- Cluster 3: Multimodal travellers (N = 107) [29.9%]
- Cluster 4: Car lovers (N = 100) [27.9%]

5.2.1 Cluster characteristics

Table 15 contains the characteristics of each cluster. All independent variables – on which the clustering process is based – remain significant in their explanatory power when cases are distributed to each cluster (see Appendix III.D. for an overview of the Chi-square tests and ANOVAs). Differences in characteristics in cluster members is ascribed to the attitudes towards statements (S:1 till S:8), travel aspect A:1, frequency of mode use and the number of cars per capita. Cluster members are also characterized by preferred mode use for different trip purposes and societal participation. Other socio-economic variables (e.g. income level,

household size or household income) do not significantly characterize cluster members (see Appendix III.D). Table 15 contains the scores on the independent variables per cluster.

	Cluster			
	C:1	C:2	C:3	C:4
Likeliness of using Mobility as a Service →	**3,8**	**1,9**	**2,6**	**1,8**
Independent variables				
A1: Healthy travel*	3,8	3,1	3,5	2,3
S1: Longer travel time, lower travel costs*	3,1	2,2	3,1	2,2
S2: Environment and car use*	4,2	3,2	3,7	2,3
S3: Car possession*	3,9	1,9	2,7	1,9
S4: Interest in new mobility services*	4,0	2,7	2,6	2,6
S5: Freedom of car*	3,1	3,8	3,4	4,0
S6: Alternatives for the car*	3,7	2,4	3,1	2,4
S7: Varying travel pattern*	3,4	4,4	2,5	2,0
S8: Travel with unknowns*	2,8	2,0	2,6	1,7
Frequency car driver (w/wo passengers)**	2,5	3,4	3,0	3,5
Frequency train**	2,8	1,9	2,3	2,0
Frequency bus**	1,6	1,3	1,4	1,2
Frequency cycling**	3,0	2,3	2,9	2,3
Number of cars per capita	,57	,73	,67	,70
Socio economic variables	C:1	C:2	C:3	C:4
Retired	22.2%	23.0%	28.4%	15.5%
Working	61.9%	59.5%	69.6%	77.3%
Self-employed	15.9%	17.6%	2.0%	7.2%
Low income < €26.200	7.6%	8.3%	6.6%	1.0%
Medium income €26.200 – 65.500	47.0%	36.9%	51.9%	53.0%
High income > €65.500	39.4%	50.0%	35.8%	36.0%
Education level – low	1.5%	3.5%	2.8%	5.0%
Education level – medium	9.2%	12.9%	18.7%	15.0%
Education level – high	89.2%	83.5%	78.5%	80.0%
Male	43.9%	68.2%	56.1%	58.0%
Female	56.1%	31.8%	43.9%	42.0%
Daily use of travel planning application(s)	22.7%	16.9%	16.0%	11.1%
No use of travel planning application(s) at all	10.6%	24.1%	25.5%	19.2%

*Table 15 Cluster composition. * Five-point scale ** Four-point scale.*

5.2.2 Cluster 1: Potential MaaS users (18.4%)

Cluster 1 contains persons who have a high intention to use MaaS (score 3.8 on a 5-point scale, i.e. likely to use MaaS). A high likeliness of using MaaS is associated with positive attitudes towards MaaS related statements, frequent use of the train, preference to use the train for different trip purposes and the lowest amounts of cars per capita (0.57 cars/capita). Also, 'Potential MaaS users' use significantly more frequent travel planning application than clusters 2, 3 and 4 (χ^2= 18.51(9), p = 0.03). These results are in line with theoretical implications for the interest in MaaS, meaning that frequent transit users and persons eager with using travel

planning application will be the 'early adaptors' of MaaS (*Kennisinstituut voor Mobiliteitsbeleid*, 2018). Cluster 1 has the highest share of females (56.1%) compared to other clusters and has a relative high share of self-employed persons.

5.2.3 Cluster 2: Frequent car drivers (23.8%)

Cluster 2 members are 'Frequent car drivers' – having a low intention to use MaaS (score 1.9 out of 5). They are characterized by very frequent use of private car use, preference to take the car for different trip purposes and having a high varying travel pattern. High income groups and males are overrepresented in the second cluster and the share of self-employed persons is also the highest of all clusters (17.5%). Relatively high car possession rates (0.73 car/capita), the preference for the private car and very frequent use of the private car are perceived as barriers for the intention to use MaaS (Karlsson et al., 2017).

5.2.4 Cluster 3: Multimodal travellers (29.9%)

Cluster 3 comprises 'Multimodal travellers'. They use different modes (car, train and bike) on the similar frequent manner. The likeliness of them to use MaaS is neutral (score 2.6 out of 5) and their attitudes towards MaaS are also mostly neutral. An assumption for the absence of the intention to use MaaS is a low score on the interest in new mobility services. A possible explanation for this is the large share of retired persons (i.e. elderly) who (almost) never use a travel planning application (holds for 25.5% of the cluster members). The lack of adroitness to use travel planning application is an important perceived barrier for the intention to use MaaS (Karlsson et al. (2017); *Kennisinstituut voor Mobiliteitsbeleid* (2018)).

5.2.5 Cluster 4: Car lovers (27.9%)

Cluster 4 members are true 'Car lovers', having the lowest intention to use MaaS of all clusters (score 1.8 out of 5). The share of working persons is the largest (77.3%), the share of retirees the lowest (15.5%) of all clusters. The private car is used the most frequent of all clusters and car possession rates are relatively high as well (0.70 car/capita). This, in combination with the low share of daily use of travel planning applications explains the lack of intention to use MaaS.

5.2.6 Answer to sub research question 2

Concerning the intention to use MaaS, four clusters are distinguished. Cluster 1 – 'Potential MaaS users', approximately a fifth of the *Paleiskwartier* population – has a true intention to use MaaS. Potential Maas users are characterized by positive attitudes towards MaaS characteristics, very frequent use of the train, preference to use the train for different trip purposes and low car possession rates. Also, the use of travel applications on a daily basis is the highest among all clusters. This implies that cluster 1 could be depicted as 'early adaptors' of MaaS in the *Paleiskwartier*. Cluster 3 – multimodal travellers, approximately 3 out of 10 *Paleiskwartier* residents – are characterized by 'typical MaaS aspects', such as multimodality and looking for alternatives for the private car. However, they have a lack of intention to use MaaS because of the low interest in new mobility concepts, the high share of non-use of travel planning applications and the over representation of elderly. Clusters 2 and 4 – together approximately half of the *Paleiskwartier* population – are the least potential MaaS users, based on their attitudes towards MaaS characteristics, low interest in new mobility services, very frequent use of the car, very infrequent use of the train and preference for the car for different trip purposes.

5.3 Sub research question 3: Which factors determine the intention to use ridesharing by Paleiskwartier students?

This section describes which factors explain the intention to use ridesharing by *Paleiskwartier* students. First, univariate statistics are presented. Second, bivariate statistics are presented, to reveal association between independent variables and the dependent variable *'interest in using ridesharing'*. Multivariate statistics are presented in the last section.

5.3.1 Univariate statistics: composition of the sample

The sample has 202 cases. 47.5% of the respondents is male, 52.5% is female. The mean age of respondents is 21.3 years (SD = 6.2), 90% of the respondents being 17-24 years. Concerning the possession of a driving license, the large majority of the students is able to drive a car (80.7%). The largest share (69.8%) of the respondents is student on the *Avans Hogeschool*. A third (30.2%) of the respondents is student on the *HAS Hogeschool*. Concerning the travel distances from home to school (see Table 16) it is concluded that more the majority (83.7%) of the students has a travel distance that is most likely to be with the use of non-slow modes (e.g. transit or the car).

Travel distance (one-way)	Percentage	Note
< 1km	1,5%	Walking distance
1 - 5 km	5,9%	Cycling distance
5 - 10 km	8,9%	Cycling distance
10 - 25 km	23,3%	Non-slow mode distance (transit or car)
25 - 50 km	34,7%	Non-slow mode distance (transit or car)
> 50 km	25,7%	Non-slow mode distance (transit or car)

Table 16 Travel distances for students in the Paleiskwartier.

Regarding mode use, see Figure 15, it is concluded that the train, bus, walking and cycling are the most used modes to reach the *Paleiskwartier*. For solo car drivers, approximately a fifth (21%) of these drives is on a regular basis. Smaller shares holds for car drivers with passenger and passengers in cars: approximately 10% is drive by car on a regular basis. The explanation for the high share transit is because of the presence of the free public transit car (88.6% of the respondents has a free transit card).

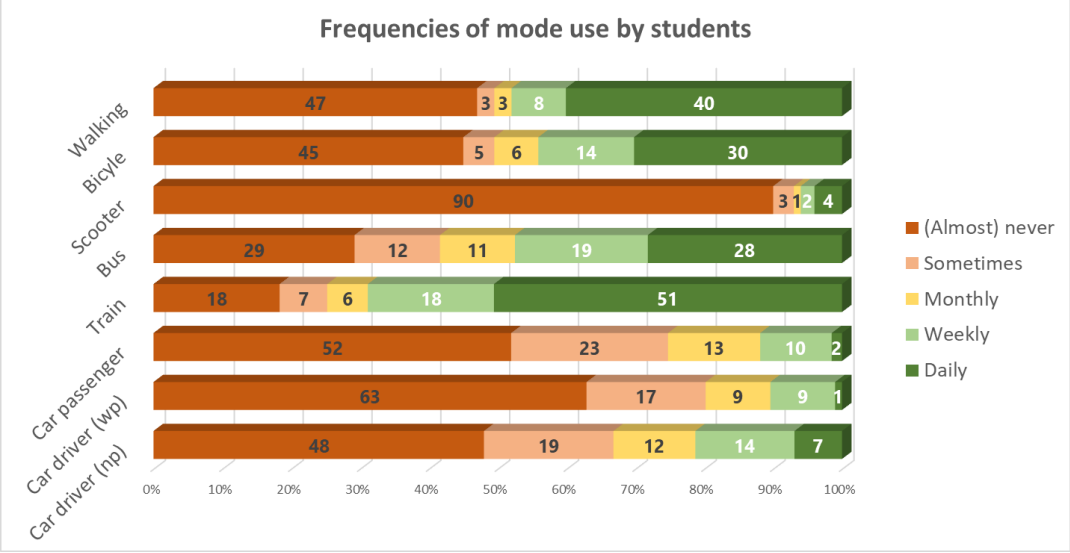


Figure 15 Mode frequencies used by students.

5.3.1.1 Travel aspects

Concerning the travel aspects, it is concluded that students evaluate travel costs, travel time and comfort as the most important. Comparing the scores with the residents of the *Paleiskwartier*, it is concluded that students evaluate travel costs as the most important attribute. This implies that costs for ridesharing could be important an important predictor for the intention to use ridesharing. Healthy travel and environment are evaluated as relatively unimportant, especially when compared with shares of residents.

5.3.1.2 MaaS related statements

Concerning MaaS related statements, it is concluded that students evaluate the freedom of driving a car as important (S:5, 66% of the respondents agree with the statement). Students are not very willing to travel with unknown persons (S:8) and do not evaluate the environmental effects of their travel behavior as important (S:2).

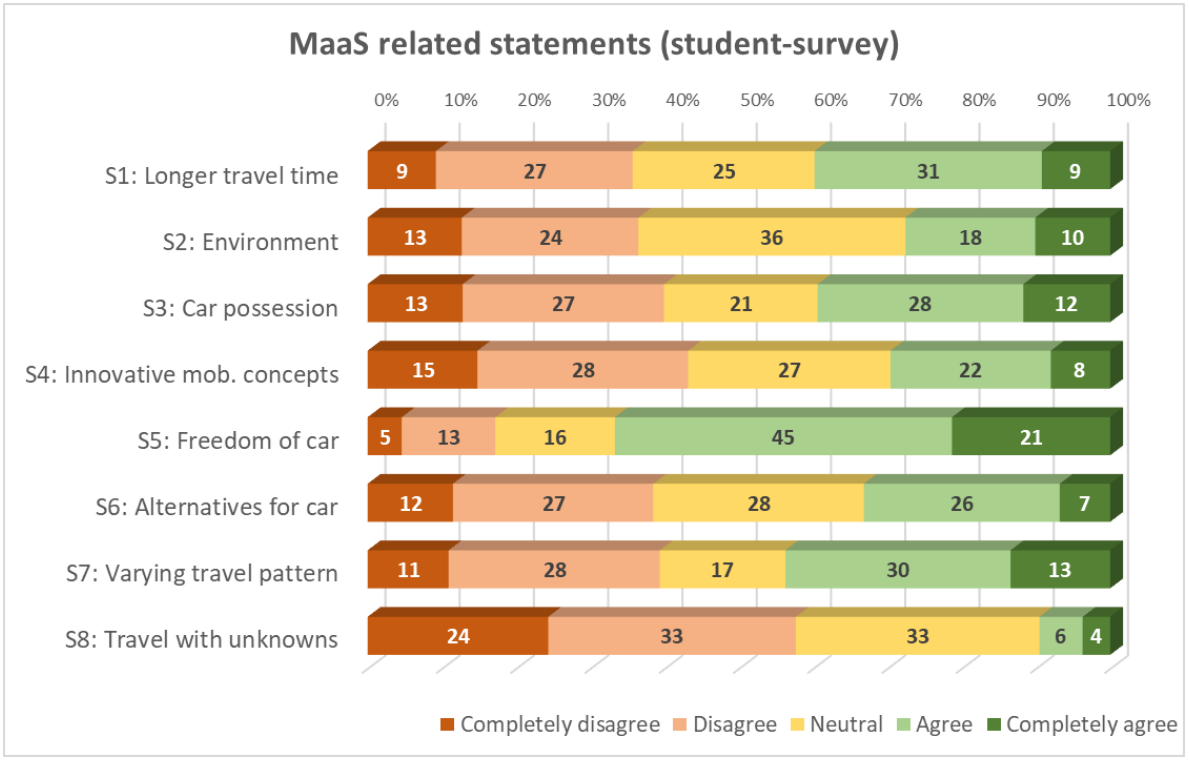


Figure 16 MaaS related statements (student-survey)

5.3.1.3 Intention to use ridesharing

Similar to the central question of the resident-survey, the intention to use ridesharing is asked on a 5-point scale. It is concluded that frequent car drivers are moderately likely to use ridesharing (33% is (very) likely to use ridesharing) and frequent car passengers/transit users are less likely to use ridesharing (19% is (very) likely to use ridesharing). See Figure 17. That frequent car driver have a higher intention to use ridesharing could be explained by the fact that this group is looking for possibilities to reduce the costs of their car trips. On the other hand, it is assumed that frequent transit users refuse to increase their travel costs (the ridesharing fee), since they have free transport possibilities due to the presence of the student public transport card. Taking the costs of ridesharing in consideration (€0.125/km), 49.5% of the respondents (N=202) is positive, 37.6% is negative and 12.9% is neutral towards this price. Concerning the experience with ridesharing, 25.2% of all respondents indicate that they have

ever taken someone with them in the vehicle. 25.8% of all respondents have ever participated in ridesharing as a passenger. The majority of the respondents (51%) has never participated in ridesharing.

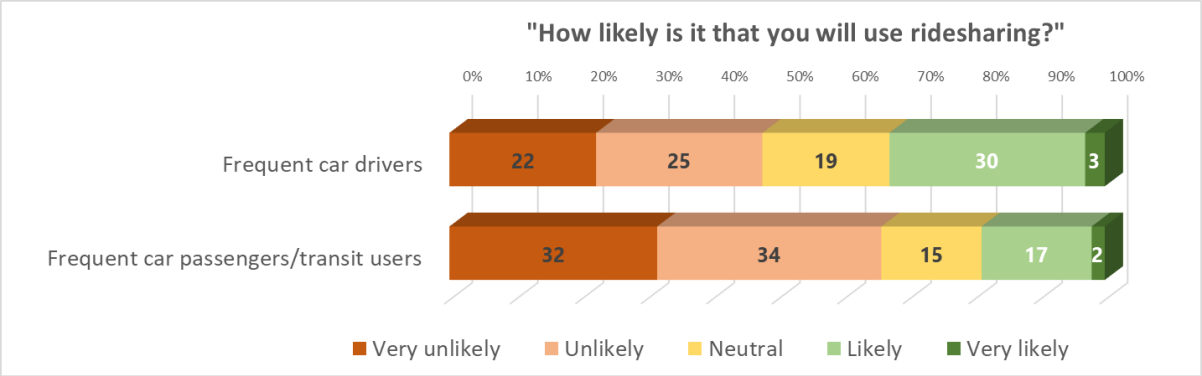


Figure 17 Intention to use ridesharing by frequent car drivers and frequent car passengers/transit users.

5.3.1.4 Ridesharing statements

Most important drivers to participate in ridesharing are reductions in travel time and reductions of the costs of the privately owned vehicle, see Figure 18. The social aspect of ridesharing (i.e. meeting new people) is evaluated negatively by students. For potential ride offering persons (N = 68, frequent car drivers), it is concluded that information of the passenger(s), receiving money and having a discount on parking are the most important motivations to offer a ride. For potential ride taking persons (all respondents), the closeness of the drop-off/pick up location is evaluated the most important. See appendix III.F for detailed information.

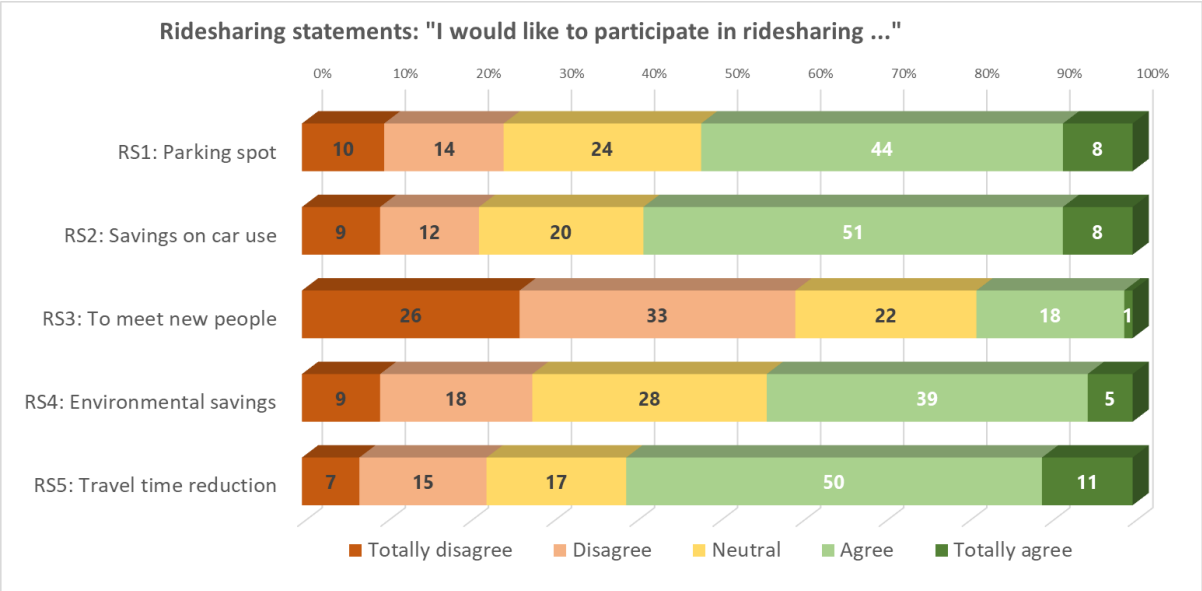


Figure 18 Evaluation of ridesharing statements by all students.

5.3.2 Bivariate statistics: composition of the sample

The dependent variable taken for the bivariate analysis is the intention to use ridesharing: *'How likely is it that you would take a ride using a ridesharing application?'* (Q19). Note that this question is asked to both existing frequent car users and frequent car passengers/transit users.

5.3.2.1 Personal characteristics: travel distance, age, driving license and transit card

Taking four personal characteristics into account, it is concluded that travel distance (F = 0.586, p = 0.673) and age (F = 2.146, p = .086) have no significant association with intention to use ridesharing. The presence of a driving license (χ^2 = 3.095(2), p = 0.213) and student travel card (χ^2 = 6.066 (4), p = 0.194) could neither explain the intention to use ridesharing. Neither gender has no association with the interest in using ridesharing (χ^2 = 2.227 (4), p = 0.694).

5.3.2.2 Mode use and intention to use ridesharing

Solely for the frequency of being a car passenger, the association with the intention to use ridesharing is significant (χ^2 = 10.125(4), p = 0.038), see Table 17. For car drivers (with or without passengers), train users and bus users, associations are insignificant. Frequencies are measured for a 3-point scale – (1) almost never, (2) regularly (monthly) and (3) frequent (daily) – to meet the demands of the Chi-square test.

Mode*	X^2 (df)	p-value	Kendall's tau-b
Car (driver without passengers)	8.844 (4)	0.065	N/A
Car (driver with passengers)	6.659 (4)	0.155	N/A
Car (as passenger)	10.125 (4)	0.038	0.012**
Train	5.005 (4)	0.287	N/A
Bus	3.513 (8)	0.897	N/A

*Table 17 Associations between frequency of mode use (measured on a 3-point scale to meet the demands of the Chi-square test) and intention to use ridesharing (measured on a 3-point scale, idem). ** insignificant.*

5.3.2.3 Statements and intention to use ridesharing

Respondents agreeing with the ridesharing statements predominantly have an intention to use ridesharing to avoid the hassle of looking for a parking spot (RS:1, χ^2 = 15.940 (4), p = 0.003) and to meet new people (RS:3, χ^2 = 19.325 (4), p = 0.001). Cost savings, a reduced environmental impact or a travel time reduction are not significantly associated with the intention to use ridesharing. See Table 18. Note that this holds for all frequent car drivers, car passengers and transit users.

Statement *"I would like to participate in ridesharing …*	X^2 (df)	p-value	Kendall's tau-b
RS1: … *to avoid the hassle of looking for a parking spot."*	15.940 (4)	0.003	0.236
RS2: … *to save on the cost of owning and using a car."*	7.488 (4)	0.112	N/A
RS3: … *to meet new people."*	19.325 (4)	0.001	0.249
RS4: … *to reduce the environmental impact of car use."*	4.963 (4)	0.291	N/A
RS5: … *to reduce my travel time from home to school, and vice versa."*	2.420 (4)	0.659	N/A

Table 18 Associations for ridesharing statements and intention to use ridesharing (N = 202).

MaaS related statements, S:2 'Environment', S:4 'Innovative mobility services' and S:6 'Alternatives for the car' are significantly associated with the likeliness of using ridesharing. Kendall's tau-b values are positive and significant (p<0.05), which indicates that the more a respondent agrees with the statements S:2, S:4 and S:6, the more the student is likely to use

ridesharing. As regards the six travel aspects, only the travel aspect 'environmentally friendly travel' is significantly associated with the likeliness of using ridesharing (χ^2= 9.476 (4), p = 0.048). All other travel aspects (i.a. healthy travel, travel costs, travel time, et cetera) do not have a significant association with the likeliness of using ridesharing.

Statement	X^2 (df)	p-value	Kendall's tau-b
S1. "I do not mind having a longer travel time, as long as the trip is less expensive."	4.259 (4)	0.372	N/A
S2: I think it is important to drive less by car, because of environmental concerns	**17.219 (4)**	**0.002**	**0.190***
S3: I do not need to possess a car, if travel alternatives would be (almost) everywhere and anytime available.	8.068 (4)	0.089	N/A
S4: Innovative mobility services (e.g. BlaBla car and Uber) make me enthusiastic	**9.949 (4)**	**0.041**	**0.214***
S5: My own car gives me a lot of freedom.	2.303 (4)	0.680	N/A
S6: I am sometimes looking for travel alternatives for my own car	**12.092 (4)**	**0.017**	**0.252***
S7: My mobility pattern varies on a weekly basis	5.113 (4)	0.276	N/A
S8: I do not mind travelling with unknown persons	6.423 (4)	0.170	N/A

*Table 19 Associations between the MaaS related statements and interest in using ridesharing. * p < 0.05.*

5.3.3 Multivariate statistics

5.3.3.1 Principal component analysis

Principal component analysis is used to investigate which independent variables are associated with the dependent variable 'likeliness of using ridesharing' (Q19). It is concluded that the intention to use ridesharing is associated with higher levels of agreement with ridesharing statements 'RS1', 'RS2', 'RS5' and MaaS related statement 'S4'. These results are in line with the expectations based on literature: the intention to use ridesharing is explained by lower needs to look for a parking spot, to save costs and travel time, which are the practical benefits of ridesharing (Deakin, et al., 2011). Intrinsic motivations in innovative mobility services are also associated with the intention to use ridesharing, which could be explained by the fact that higher adoption rates of new mobility services are achieved when individuals are intrinsically motivated in these new forms of mobility (Tezcan, 2016).

Lower rates of intention to use ridesharing are associated with frequent use of the bike and a high evaluation of healthy and flexible travel. The lack of intended use is explained by the fact that for short travel distances, the bike is preferred over the car, because of the lower costs and ease to use. The importance of healthy travelling is associated with high levels of bike use as well. These conclusions are assumed relevant for the Dutch context (Rietveld & Daniel, 2004). Students having a high importance of flexible travel have a lower rate of intention to use ridesharing. This could be explained that ridesharing requires some loss of flexibility (e.g. a specific pick-up and drop-off time).

For potential ride offering persons (N = 64) – see Table 21 – it is concluded that the interest in offering a ride is associated with ridesharing statements 'RS:3' and 'RS:4', which are social and

environmental reasons, respectively. Also, a varying travel pattern ('S:7'), no matter of travelling with unknown persons ('S:8') and the possibility to win a price ('SP:5') explain the interest in offering a ride for frequent car drivers. A low importance of travel costs ('A:2') and information about the ridesharing person ('SP:1') are associated with higher interest rates in offering a ride. Interestingly, no financial stimuli (except the awards) are associated with the interest in offering a ride, which is not line with research (Deakin, et al., 2011).

Components for ride taking persons	C1	C2
Ride taking: How likely is it that you would use ridesharing?	**0,51**	**-0,52**
Frequency cycling		**0,40**
RS1: *... to avoid the hassle of looking for a parking spot."*	**0,77**	
RS2: *... to save on the cost of owning and using a car."*	**0,67**	
RS5: *... to reduce my travel time from home to school, and vice versa."*	**0,54**	
S4: Innovative mobility services makes me enthusiastic	**0,40**	
A1: Healthy travel		**0,39**
A6: Flexible travel		**0,73**

Table 20 Principal Component analysis for ride taking persons.

Components for ride offering persons	C3	C4
Ride taking: How likely is it that you would use ridesharing?	**0,64**	**0,46**
RS3: ... to meet new people."	0,80	
RS4: ... to reduce the environmental impact of car use."	0,52	
S7: "My mobility pattern varies on a weekly basis."	0,43	
S8: "I do not mind travelling with unknown persons."	0,67	
A2: Travel costs		-0,42
SP1: ... when I have information about the ride sharing person		0,84
SP5: ... when I participate in a contest (the winner receives a price)	0,43	

Table 21 Principal Component Analysis for ride offering persons.

5.3.4 Multivariate statistics: intention to use ridesharing by *Paleiskwartier* students

Ordinal logistic regression is used to indicate which independent variables could significantly predict the interest in using ridesharing. It is concluded that the following independent variables could significantly explain the intention to use ridesharing:

- RS1: "I would like to participate in ridesharing to avoid the hassle of looking for a parking spot"
- RS3: "I would like to participate in ridesharing to meet new people"
- S3: "I do not need to possess a car, if travel alternatives would be (almost) everywhere and anytime available."
- A6: Flexible travelling

The final log likelihood (-2LL) of the model is 161.489 ($p < 0.000$) and Nagelkerke's R^2 is 0.216. The test of parallel lines is insignificant ($\chi^2 = 5.176$ (8), $p = 0.739$) indicating that the slope parameters are not similar across response categories and therefore is in compliance with the prerequisites of ordinal logistic regression. Note that the 3-point Likert scale is used for the dependent variable (Q19 – Intention to use ridesharing) and the 3-point Likert scale is used for

independent variables. No interaction effects can be found among the independent variables. As could be seen in Table 22, it is concluded that if students are more negative towards statements 'RS1', 'RS3' and 'S3', the less it is likely that they would participate in ridesharing. For students that are more positive towards these significant statements, the likeliness of using ridesharing is larger. This is in line with the expectations based on literature (cf. Tezcan (2016) & *Kennisinstituut voor Mobiliteitsbeleid* (2018). Students are willing to use ridesharing to reduce the hassle of looking for a parking spot, which is an explanatory variable from a practical perspective.

Ordered logit model – student survey	**Estimate**	**Std. Error**	**Wald**	**df**	**Sig.**	**95% Confidence Interval**	
Variable						**L.B.**	**U.B.**
Intention to use ridesharing ([very] unlikely)	**-1.014***	**.409**	**6.140**	**1**	**.013**	**-1.817**	**-.212**
Intention to use ridesharing (neutral)	-.060	.402	.022	1	.881	-.848	.728
Interest in using of ridesharing ([very] likely)	0	.	.	0	.	.	.
RS1: Less hassle of looking parking spot ([totally] disagree)	**-1.633***	**.475**	**11.808**	**1**	**.001**	**-2.564**	**-.701**
RS1: Less hassle of looking parking spot (neutral)	**-.836***	**.412**	**4.110**	**1**	**.043**	**-1.645**	**-.028**
RS1: Less hassle of looking parking spot ([totally] agree)	0	.	.	0	.	.	.
RS3: Ridesharing to meet new people ([totally] disagree)	**-1,202***	**,419**	**8,213**	**1**	**,004**	**-2,024**	**-,380**
RS3: Ridesharing to meet new people (neutral)	**-1,267***	**,500**	**6,424**	**1**	**,011**	**-2,246**	**-,287**
RS3: Ridesharing to meet new people ([totally] agree)	0	.	.	0	.	.	.
S3: Car possession ([totally] disagree)	**-,940***	**,381**	**6,082**	**1**	**,014**	**-1,686**	**-,193**
S3: Car possession (neutral)	-,701	,446	2,470	1	,116	-1,575	,173
S3: Car possession ([totally] agree)	0	.	.	0	.	.	.
A6: Flexible travel ([very] unimportant)	**1,215***	**,522**	**5,429**	**1**	**,020**	**,193**	**2,237**
A6: Flexible travel (neutral)	**,893***	**,417**	**4,596**	**1**	**,032**	**,077**	**1,710**
A6: Flexible travel ([very] important)	0	.	.	0	.	.	.

*Table 22 Parameters of the ordinal logistic model for the student-survey. * p<0.05.*

Also, students interested to meet new people are more likely to participate in ridesharing, which is in line with the social aspect of ridesharing (Tezcan, 2016). Concerning MaaS related statement 'S:3', students indicating that they definitely prefer to possess a car rather than

widely available transport alternatives, are less likely to use ridesharing. Travel aspect 'A:6' has positive β-values for the lower scores on the travel aspect, indicating that people evaluating flexibility of their choice of travel mode are less more likely to use ridesharing. An explanation for this could be that the private car is seen as 'a flexible' mode (since it provides door-to-door transport) and if students do not evaluate this door-to-door principle that much, they are earlier inclined to use ridesharing. In line with the results of ordinal logistic regression analysis for *Paleiskwartier* residents, cumulative probabilities are calculated for significant independent variables, see Table 23. Note that cumulative probabilities for answer category 'neutral' of the likeliness of using ridesharing are insignificant (p = 0.881) and could therefore not be interpreted.

	Q19: How likely is it that you would use ridesharing?		
	(very) unlikely*	Neutral**	(very) likely*
RS1: Less hassle of looking parking spot ([totally] disagree)	65%	18%	17%
RS1: Less hassle of looking parking spot (neutral)	46%	23%	32%
RS1: Less hassle of looking parking spot ([totally] agree)	27%	22%	51%
RS3: Ridesharing to meet new people Innovations ([totally] disagree)	55%	21%	24%
RS3: Ridesharing to meet new people Innovations ([totally] agree)	27%	22%	51%
S3: Car possession ([totally] disagree)	48%	23%	29%
S3: Car possession([totally] agree)	27%	22%	51%
A6: Flexible travel ([very] unimportant)	10%	12%	78%
A6: Flexible travel (neutral)	13%	15%	72%
A6: Flexible travel ([very] important)	27%	22%	51%

*Table 23 Cumulative probabilities for the significant independent variables of the ordinal logistic model. * significant (p< 0.05) ** insignificant (p => 0.05)*

5.3.5 Answer to sub research question 3

Paleiskwartier students evaluate travel costs as the most important aspect for mode choice. A third of the frequent car drivers has an intention to use ridesharing. 2 out of 10 frequent transit users/car passengers has an intention to use ridesharing. The intention to use ridesharing is motivated by a reduction of travel costs and time, less hassle of looking for a parking spot and meeting new people during ridesharing. Students evaluating flexible travelling as (very) important, are less inclined to use ridesharing.

Note on representativeness

The sample (N = 202) is not representative for the whole student population (N = 17,508). This, since for a confidence level of 95% (two-sided), at least 470 cases are needed (including a 25% safety margin). Despite the lack of representativeness, results presented in this section indicate that for a specific group of students, the intention to use ridesharing could be explained.

5.4 Sub research question 4: What expectations do public and private actors have on the inclusion of societal goals in MaaS?

This paragraph describes the expectations of public and private actors on the inclusion of societal goals in MaaS. First, the definition of MaaS according to public and private actors is given, followed by their expectations on the inclusions of societal goals in MaaS. Also, steering on travel behavior is discussed.

5.4.1 Definition of Mobility as a Service

From the perspective of the public transport authority – the province Noord-Brabant – the positionality of Mobility as a Service in the transportation system is described as follows (Interview 1, 2018):

'Mobility as a Service is a concept that better fits [than existing transit] to the **demand of travellers**. MaaS is not aimed from an environmental perspective per se. For the province of Noord-Brabant, it is not very logic **to force demand for a sustainable product**, but to provoke demand for a product [like MaaS]. It is very difficult for a government to steer on sustainability, since it is unknown what travellers' alternatives for MaaS would be.'

This point of view is different from the vision of the public transport authority (PTA) in the research of Smith et al. (2018). The Swedish PTA divides between societal aims and business goals and aims at steering private developments for what is best for society. The policy maker of the Ministry of Infrastructure and Waterworks thinks that MaaS is not solely as a concept that better fits to travellers' demands, but provides a more transparent insight in travel alternatives (Interview 2, 2018):

'One of the key aspects of MaaS is that there is a more **transparent insight in the costs**, travel **alternatives, comfort and sustainability** than existing travel planning applications. MaaS is an IT integration-solution for all the supply of transport alternatives, MaaS is not 'thing on itself'.'

A policy maker of the municipality of 's-Hertogenbosch agrees with the state policy maker. He thinks that multimodality and integration of different modalities is one of the key aspects of Mobility as a Service. On-demand travel advice could be a vital extension of MaaS (Interview 5, 2018). This is in line with the thought of MaaS integrator "B". An employee of MaaS integrator "B" states that one of the key aspects of MaaS is that the consumers will receive real-time advices regarding the travel from A to B. These real-time advices are adapted to the preferences of the MaaS app user. The relevance of a uniform definition is one of the key aspects of a vital MaaS pilot that a municipal policy maker points out. He thinks that the last two years the 'pure' definition of MaaS has weakened towards *'everything that has to do with sharing modalities is called MaaS'*. Of importance for the feedback and learning of MaaS pilots, is that the right definition of Mobility as a Service is understood and used by all involved stakeholders (Interview 5, 2018).

The definition of Mobility as a Service in policy documents
The Ministry of Infrastructure and Waterworks defines Mobility as a Service as 'the supply of multi-modal, demand-oriented mobility services, in which tailored travel opportunities via a digital, real-time platform is offered to costumers. Payment and transactions are included in the platform. The goal of MaaS is offering mobility services to customers that is better in meeting the wide range of demands of travelers than existing transport services (Ministerie van Infrastructuur en Waterstaat, 2018).

The province of Noord-Brabant concludes that '*the demand for public transport changes, traditional bus stops will be replaced by demand responsive transportation*'. Mobility as a Service will supplement and enrich existing public transportation. Like Spotify for music, MaaS could be the service for transportation: an integrated, complete supply of different transport modes, offered in one subscription (Provincie Noord-Brabant, 2018).

5.4.2 Inclusion of societal goals

That the definition and positionality of Mobility as a Service is dependent on the political situation, elaborated by Meurs et al. (2018), is subscribed by the provincial policy makers. Incorporating societal goals in Mobility as a Service (MaaS level-4) is clearly difficult for them, mainly due to legitimacy (Meurs, et al., 2018). As the policy makers of the province Noord-Brabant indicate (Interview 1, 2018):

'It is only possible to **incorporate collective values** in MaaS if you have **legitimacy** as a governmental body. The province has legitimacy to control public transportation in the provincial area, but it is difficult to directly steer on Mobility as a Service [e.g. on service aspects]. **Stimulation** could via **financial means**, e.g. subsidies for the use of zero emission vehicles for a MaaS pilot.'

Regarding the role of the municipality of 's-Hertogenbosch, this could be described as facilitating. As a policy maker indicates, the role of the municipality of the MaaS pilot is – until now – predominantly facilitating (Interview 5, 2018):

'Guaranteeing shared mobility services requires **financial and legal means** from the municipality. For example, for the shared cars, we had to financially compensate the non-collected parking fees and we had to implement **new parking policies** in the neighbourhood.'

According to the private MaaS integrator "B" the public parties have a different aim of Mobility as a Service than private parties, but they both aim at reduced congestion:

'The **MaaS integrator** steers towards a **desired behavior**, which is in line with the demands of the user (in the case of the pilot, the employee) and the client (the employer): the focus is here on the individual level, with communal benefits. **The government** aims at reducing congestion or to stimulate innovations (**communal advantages**), but it is very difficult to translate these communal advantages to the individual level. If you could **couple the interests** of the government, employee and employer, then the development of MaaS could **accelerate**.'

MaaS integrator "A" evaluates that steering on desired behavior is a terminology that is typically used by governments. The private MaaS integrator focuses more on the demands of the user (Interview 4, 2018):

'We predominantly focus on **users and their demands**. The central question is *"what is the consumer aiming for?"*. The answer to this question is **marketing** and we have been using that for ages. I believe in consumer marketing, especially bottom-up marketing from the consumers themselves, instead of **government-wise steering** on consumers.'

In a similar manner MaaS integrator "B" agrees but foresees a strong added value in coupling user demands with an added value for employers or governments (Interview 3, 2018). The positionality of MaaS in the existing transport system is describes by the policy maker of the Ministry of Infrastructure and Waterworks as follows (Interview 2, 2018):

'We do not see MaaS as a last mile transport solution but being part of the public transport system. Of course, **travellers** will use the **existing public transport** system, but new (shared) **mobility concepts** [i.e. MaaS] could easily **enrich** the existing transport system, leading to a more **attractive public transportation system**.'

The province Noord-Brabant details this position of MaaS in the existing public transport system according to the 'quadrant system of public values of PT', in which (1) collectivity, (2) public values, (3) personal gain and (4) autonomy are part of. Conventional public transportation has a high degree of collectivity and public values, where MaaS has a high degree of personal gain and autonomy (de Provincie Noord-Brabant, 2018). *'Research indicates that the largest effect [i.e. a high number of costumers of public transportation] will be reached when all four quadrants are balanced. The existing PT system is not in balance, but with the addition of MaaS the system will be more in balance.'* (de Provincie Noord-Brabant, 2018, pp. 10). From a policy perspective, the province Noord-Brabant has divided its public transport system into three components: (1) travel-direct, (2) travel-flex and (3) travel-together. This is done to smoothen the incorporation of MaaS in the longer run.

5.4.3 Travel behavior and Mobility as a Service

The MaaS pilot MijnReisPortaal (translated 'MyTravel Portal', designed by MaaS integrator "B") has started due to the merge of two hospitals in Amsterdam (called 'AMC' en 'VUMC'). The direct reason to start a MaaS pilot is the creation of a new mobility plan for the hospitals' employees: due to the merge of the hospitals, more traffic movements would arise between the hospitals. Especially since the two hospitals are located in different locations in Amsterdam. The added value of MaaS regarding the new mobility plan is described by one of the employees of the MaaS platform MijnReisPortaal as follows:

'The advantage of the new mobility service **MijnReisPortaal** is that employees do not have to hassle with **declaration forms** for their inter-hospital trips. It does not only save time, but also costs, since it is very costly to manually process all travel declaration forms. Another reason to introduce the mobility service is to **reduce car use.** It was investigated that employees would earlier choose to come by car to the hospital, if they knew ex-ante that they had to travel on the same working day between the two hospitals.'

The physical card was needed to enter for example transit stations. Hospitals' employees used the physical travel card very frequent and evaluated it positive. This could be explained by habitual behavior, since a lot of frequent Dutch transit travellers are already used to have a physical card to travel with public transportation. Regarding the second key reason to use the mobility service – reducing car movements between the hospital – it is very important to create continuously incentives for the consumer to keep on using the mobility service application. Since the use of the application creates financial savings for the employer, these savings could be shared with the employees could:

'The change of travel **behavior** is a very time consuming and costly process and the behavioural change would stop if there would not continuously be **incentives** for the consumers. This, because the users constantly ask themselves *"what's in for me, using this application?"*.

MaaS integrator "A" does not foresee the need for a steering role on behavior – of what is proposed in MaaS level 4. It is of opinion that steering of behavior is a very government-typical terminology. The MaaS integrator believes in clearly looking at the demands of the traveler – 'what does the consumers want?' – which is used in marketing. Especially bottom-up marketing – direct feedback from users – could be helpful for improving the MaaS service (Interview 4, 2018)

5.4.4 Answer to sub research question 4

Both public and private actors agree that it is difficult to include societal goals in MaaS. The public transport authority emphasizes that the lack of legitimacy is one of the most important barriers for the inclusion of societal goals. It is also difficult to outweigh different societal goals for the public transport authority. In addition, the translation of societal goals in specific incentives or travel advices is perceived as difficult, by public and private actors. Private MaaS integrators have predominantly a focus on individual travellers' needs rather than over coupling societal goals. They call this 'the added value' of MaaS for both the consumer (traveler) and employer/government. Chapter 6 will discuss the inclusion of societal goals in MaaS in detail.

5.5 Sub research question 5: What opportunities and barriers are experienced by the MaaS integrator and public transportation authority regarding the organization of Mobility as a Service?

The fifth sub questions is answered first by looking at which roles public and private actors have taken concerning the organization of the pilot in the *Paleiskwartier*. Hereafter, the selection procedure of the MaaS integrator is discussed. The section is concluded with operational details and data.

5.5.1 Public roles in the process

As Mukhtar-Landgren & Smith (2018) indicate, the role for the government could be either as (Mukhtar-Landgren & Smith, 2018)

- **A promotor:** actively stimulating innovation,
- **An enabler:** financially and legally enabling innovations in a spatial context,
- **A partner:** in which the public party is an active partner in the actor network

Regarding the pilot in *het Paleiskwartier*, it is concluded that the municipality predominantly had the role of an enabler. This is concluded from the financial and legal steps that are taken to, for example, implement shared cars. It also has the involvement of a partner, since the municipality is involved in the public-private partnership. The role of the province Noord-Brabant could be seen as a mix between an enabler and a partner. The province provides financial means for the private MaaS integrator "A" (enabler) and is involved in the public-private partnership (Interviews 1 and 5, 2018). The level of involvement in the private MaaS integrator "A" is not as active as would be expected from 'high degree of involvement' by the province (Interview 1, 2018):

5.5.2 Development of MaaS: a task for public or private organizations?

Roles of governmental bodies, as described by Mukthar-Landgren & Smith (2018), are related to the *'development scenarios for MaaS'* described by Smith et al. (2017b). The development of MaaS in the province Noord-Brabant could be described as a public-private development. However, the exact definition of Smith et al. (2017b) is not applicable for the Noord-Brabant case. Smith et al. (2017b) describe this public-private development as:
'… the public sector contributes to the development by taking on the integrator role (in addition to the actions described in the market-driven scenario), which proponents argue will result in a lower initial investment cost for MaaS operators, as they will not have to develop an integration platform. Another potential benefit of this scenario that proponents foresee is that a publicly controlled integrator could act as a 'neutral buffer' between MaaS operators and transport providers, thus, mitigating the risks of MaaS operators becoming too dominant.' (Smith et al, 2017b, pp. 7). This means that the public transport authority will be mainly responsible for the integration of modalities and private organizations responsible for the operation of MaaS.

This is not the actual case for the public transport authority in Noord-Brabant, as been described in the policy document 'Vision towards shared mobility 2018' (de provincie Noord-Brabant, 2018). The role of the PTA is herein described as a 'market master', in which: *'the standardisation of data is enhanced by multilateral talking between different smartphone application. This in accordance with national and EU legislation and policies on data'* (de provincie Noord-Brabant, 2018, pp. 20). The aim of the public transport authority in Noord-Brabant is not on the integration of data itself, but rather creating a level playing field for different market parties that are involved in Mobility as a Service: *'we aim for a level playing field for all involved market parties, both existing and upcoming MaaS integrators and operators. This, so that those market parties could provide smart solutions for shared mobility.'* (de provincie Noord-Brabant, 2018, pp. 20).

The knowledge function of the province turned out to be very important in the process of forming alliances between public and private parties, as been investigated for the MaaS pilot in Nijmegen (Netherlands) by Meurs et al. (2018). *'Knowledge is a key resource in terms of value creation in a MaaS alliance requiring separate attention. Actors may enter alliances in order to improve their knowledge on integrated mobility services through collaboration. Access to knowledge may be more important than the acquisition of knowledge from the partners.'* (Meurs et al., 2018, pp. 10).

5.5.3 Data sharing

Openness in data sharing is acknowledged by the policy makers of the province of Noord-Brabant. A well-know concept is 'MaaS plug box' in which an independent, non-commercial parties captures all data from MaaS integrators and thereafter provides those date for MaaS operators (providers). From conventional public transportation in the Netherlands, the database NDOV[10] is an example of a 'MaaS plug box' (CROW, 2018). The 'MaaS plug box' is part of the 'standardization of data' (Meurs et al., 2018) and is evaluated by the policy makers of the province as follows:

'The **MaaS plug box** is the connector between the private MaaS integrators and MaaS operators. In this MaaS plug box, data are shared and are part of an independent, non-commercial organization. At this moment, MaaS integrator "A" develops their application by themselves and it turned out to be difficult to integrate modes, because other commercial parties were not willing to participate.'

The policy makers acknowledge that it is from an organizational and financial perspective difficult to create such a 'MaaS plug box'. This is in line with conclusions of the report 'Interoperability of Mobility as a Service' in which it is argued that an independent organization creating the 'MaaS plug box' is costly and restricts innovation. A MaaS governance model, called 'MaaS scheme', in which all MaaS operators en integrators are member is a more vital solution for standardization of data (Enigma Consultancy, 2018). Smith et al. (2018a) conclude – in line with the viewpoint of the provincial policy makers - that *'… technical and contractual harmonization was said to be needed to enable technical integration and the development of attractive MaaS offerings.'* (Smith et al., 2018, pp. 10).

MaaS Integrator "B" emphasizes that a MaaS plug box could be harmful for innovations of MaaS integrators: if innovations or developments are processed of MaaS integrators (e.g. because of demands of the client) and those data are directly processed to the MaaS plug box, other MaaS integrators could use these innovative solutions for the own business. This remains a commercial motive against the MaaS plug box, which is in line with the side notes of the report of Enigma Consultancy (2018). On the other hand, also benefits of a MaaS plug box are seen by the employees: it creates uniformity how data are stored, which could make the application wise integration of different modalities easier.

'Our **attitude** [towards MaaS operators] in the collaboration is a little **reactive,** meaning that we only act pro-active when it is necessary, since we think that **market parties** could have a better **pro-active** role than the province. Regarding the pilot in 'the *Paleiskwartier*', we **learn over time** what capabilities a market party like MaaS platform "A" has and what goes wrong in the process. We should have been a little bit **more directive** to MaaS integrator A, but you learn these things throughout the process.'

A policy maker of the municipality of 's-Hertogenbosch evaluates the co-productive environment – in which the MaaS pilot in the *Paleiskwartier* is situated – as very positive. He thinks that directive behavior – being part of a traditional client-contractor construction – increases risks for the public parties and reduced the 'shared vision on the project' (Interview 5, 2018):

[10] NDOV is the abbreviation for National Database for Public Transportation.

'We started a **co-productive environment**, which creates a shared vision *"we would like to succeed the pilot"*, rather than the declaration structure that is part of the traditional client-contractor collaboration'

The municipal policy maker also emphasizes that trust is an important aspect of the co-productive environment, especially when there are delays in the operation of Mobility as a Service. The absence of procurement procedures make that so called 'hard policy measures' (cf. Mukthar-Landgren & Smith (2018)) are not implemented for the pilot in the *Paleiskwartier*, mainly because the ex-ante scope of the pilot was difficult to estimate (Interview 1 and 5, 2018). Hard, reactive policies measures – e.g. fines when delays occur – are not appropriate for MaaS pilots, according to the municipal policy maker, since it is both for public and private parties difficult to ex-ante estimate what problems would occur with the operation of MaaS (Interview 5, 2018). The Ministry of Infrastructure & Waterworks make use of 'harder' policies, since they include a procurement procedure in the selection procedure of MaaS providers. Hereafter, MaaS providers should comply to a set of rules that are described in the contract (Interview 2, 2018).

5.5.4 Public-private cooperation

Cooperation between the public and private actors is an important element of the MaaS ecosystem. In the case of alliances, information distribution among public and private parties might be difficult (Meurs, 2018). This is also the case for Mobility as a Service in the *Paleiskwartier*, according to the policy makers of the province Noord-Brabant:

'In the **starting phase** of MaaS in the *Paleiskwartier*, a large transit company was involved in the process, in addition to the small mobility provider "A". But somehow, the **relationship** between the large en small company **was difficult**. We could not get any sense of the exact reason why they struggled with each other. Maybe it has to do with data exchange or commercial value, but the exact reason why the large transit company left the pilot is still unclear…'

The position gained by the small MaaS integrator "A" is contradict to what may be characteristic to standard situations in alliances: *'Smaller firms in an alliance may in this respect be subordinate to the larger partners, hence reducing the chances for these smaller organizations to achieve their strategic goals.'* (Meurs, 2018, pp. 11). Part of these alliances is the communication with the public transportation organization. It is concluded by the provincial policy makers that large, existing public transportation companies have more experience with communicating with public organizations (interview 1, 2018):

'Both small SME and large public transport organizations have innovations in their systems, aiming for Mobility as a Service. However, what I remarked is that large, existing **transport companies** are more used to **work together** with us. The game between public and private parties, what we have during the distribution of concessions, is better known by large transit companies than by small firms like MaaS Integrator "A". I believe that **innovation** come from **small parties**, but the big question is how large firms deal with this. **Big parties** like the large public transport firm here would like a cooperation with small MaaS providers via **existing concession** laws. For the latter, we do not aim from as a province, in the long run.'

For the case of the *Paleiskwartier*, MaaS integrator "A" indicates that there is no 'level playing field' regarding the prices related to the MaaS service. Conventional public transportation companies (i.e. the Dutch Railways 'NS' or bus company 'Connexxion') have full access to different pricing mechanisms (e.g. reductions), where the private MaaS integrator "A" only has access to a very small selection of these pricing mechanisms. The absence of a 'level playing field' also holds for real-time information about transit vehicles (which are not available for private MaaS integrators). MaaS integrator "A" thinks that it remains very difficult for conventional transit companies to share data, because of a reduced market share those transit companies in the future (Interview 4, 2018). A large transit operator involved in the case study area indicates that the absence of clear agreements for saving and distribution of traveller data is the reason why they are reserved to share (lots) of traveller data (telephone interview, December 2018).

5.5.5 Selection procedure of MaaS integrators

Important in alliance forming is the selection of the private actors providing the MaaS service. The province of Noord-Brabant uses a different approach than the Ministry of Infrastructure and Waterworks. The selection of the MaaS provider for the pilot in the *Paleiskwartier* has evolved via a natural way (Interview 1, 2018):

'It is quite **difficult** to find **Maas providers**, since the market is not very large. There is a provider called "X", but that company was at the time of decision not ready for Mobility as a Service. The selection of the MaaS provider **"A"** is somewhat **natural**, they have been involved in a lot of starting conversations and they were part of the SCRIPTS project. In addition, they are situated in the province, which provides them a small advantage as well.'

Contrary to the selection procedure of the province, the Ministry of Infrastructure and Environment uses a tendering procedure to select market parties that could offer the MaaS service. Herein, MaaS providers have the opportunity to subscribe for a 'framework tendering' (*Dutch: raamwerkcontract*). However, this is tendering procedure is criticised for its lack of innovating possibilities and for being a delay factor in the process (Smith et al., 2018). Contractual agreements are difficult to arrange for two reasons: (1) MaaS is a new product with an uncertain impact and (2) contracts would arranged between actors who have not previously collaborated (or have differences in working cultures) (Smith et al., 2018, pp. 8).

There is not solely a public-private connection in the pilot in the '*Paleiskwartier*', there is also public-public relationship, i.e. the relation between the municipality (the legal responsible for public spaces, parking, et cetera) and the province (the legal responsible for transit). Especially in the selection of geographic locations for MaaS pilots, there is a high degree of interconnectivity between the two governmental layers:

'We [the province] did not choose the geographic **location** for the MaaS pilot in the *Paleiskwartier*. The municipality of 's-Hertogenbosch chose the location. Mainly large **municipalities** are interested in MaaS, mostly from the perspective of **gains and effect**: e.g. a more sustainable look of the municipality or a reduction of parking lots. Smaller municipalities do not see any possible future advantages of MaaS, I think most of the smaller ones even do not know MaaS at all.'

The private MaaS integrator "A" evaluates the choice for involvement in the pilot in the *Paleiskwartier* not very positive from the perspective of solving an environmental problem. Integrator "A" thinks that MaaS should provide a solution for a problem (e.g. vitality or sustainability of a geographic area), rather than indiscriminately offering MaaS in a geographic area (interview 4, 2018):

'For another MaaS project in Paris, we foresee a clear role in providing a **solution** for an environmental problem, which is very **tangible**. If I speak of the *Paleiskwartier*, I do not see very big issues in terms of **accessibility** and **liveability**: which **problem** do we have **to solve** here in 's-Hertogenbosch?

5.5.6 Operational aspects, delays and communication

The development of MaaS applications is evaluated as a difficult process, being part of an open innovation (Smith et al., 2018). As the policy makers of the province evaluate for the delays in the development of the MaaS application (Interview 1, 2018):

'The **implementation** of the **MaaS app** takes **longer** than expected. We trust on a market party that it makes a valid estimation of the duration of making a MaaS application, because the province is not able to make an application by itself. But it turned out that this time **estimation was far from accurate.'**

Delays in the process are not solely evaluated by the province as a barrier, but is also experienced by one policy employee of the Ministry of Infrastructure and Waterworks (Interview 2, 2018):

'Often it is said that **delays** are caused by **technical problems**. But to be honest, I think, technically, it is possible to integrate all transport modes. I think it has to do with the (business) values of companies and organizational issues. [...] We try to act like a **trustful party** in the process, to let all involved market parties trust each other and to force for example openness in **data sharing**.'

In contrast, the MaaS Integrator "B" foresees a lack of 'technical maturity' of some mobility providers as the main barrier for the operation of a MaaS application. Especially technical delays are difficult to estimate, since some – ex-ante – simple technical integration lasts over ten times longer than expected (Interview 3, 2018). A lack of technical maturity of some mobility providers is acknowledged by MaaS integrator "A": for example, mobility provides could easily connect to its API with a full data integration, where some mobility providers only could provide a QR code instead (no data integration) (Interview 4, 2018).

Inventive solutions have to be found for some integration issues: from difficulties with Bluetooth keys till a physical mobility pass. In line with the statement of the policy maker of the Ministry of Infrastructure and Waterworks, the employees of MaaS Integrator "B" foresees that commitment of the end user to make use of the MaaS service is of huge importance, in combination with the mobility problem-solving nature of Mobility as a Service:

"**Commitment** of the user/buyer to make use of the MaaS service is very important. We have had a pilot in Rotterdam in which a lot of parties have committed towards (shared) goals, but eventually, it turned out to be very difficult to make these shared goals ready for operation and actual use of the service [...] I believe that **MaaS** is only **vital** if it provides a **solution for problem(s)** of transportation, like the case of transport issues between two hospitals."

In line with the statement of the policy maker of the Ministry of Infrastructure and Waterworks, MaaS integrator "A" thinks that a lack of trust and a lack of knowledge could explain delays in – for example – the exchange of data. It is assumed that this has to do with the education background of – predominantly – mobility providers (Interview 4, 2018):

'We see that a lot of **enthusiasm** is taken away when we describe the full process of **data exchange,** because mobility providers then think like *'what is going to happen with my data?'* and *'what will happen with our commercial position?'*. It think it has to do with their business **background**, since more **technical oriented** person look more into practical issues with the data exchange, rather than their commercial position'

The question arises whether this lack of cooperation of different (private) parties could be estimated ex-ante. MaaS integrator "A" has tried to evaluate the 'force field' before the pilot started, but during the process the interrelationships between different private actors change quite much. Especially when delays occurred, it was very difficult to tackle what the (technical) cause of the delay was and how it could be solved by MaaS integrator "A" (Interview 4, 2018).

5.5.7 Answer to sub research question 5

The barrier experienced by the MaaS integrator "A" is the lack of a level playing field with existing transit companies. This concerns the minimal available tickets of large transit companies and the lack of real-time, open data about transit vehicles. The public transport authority experiences the following barriers: (1) an unclear role division and (2) a lack of transparency in the process by the MaaS integrator. Opportunities for a vital cooperation between public and private actors, when setting up MaaS, are (1) trust, (2) commitment towards shared goals and (3) openness in data and information. Chapter 6 will discuss the barriers and opportunities in detail.

Chapter 6

Conclusion and discussion

▲ Impression of the to-be-build apartments in the *Paleiskwartier*. After completing all building projects, the neighbourhood will have 2,070 residential accommodations within 45 hectares.

6 Conclusion and discussion

This section presents most important conclusions that could be derived from the results of the surveys, focus group, semi-structured interviews and policy document analysis. All results are discussed concerning scientific research on Mobility as a Service. Also, directions for future research on explanatory factors for the interest to use MaaS and the inclusion of societal goals in MaaS are described.

6.1 Main research question

As been stated in 1.2, the goal of this research is to reveal which factors explain the intention to use MaaS by *Paleiskwartier* residents and to evaluate the process of setting up MaaS. The main research question is:

Which factors explain the intention to use Mobility as a Service and which barriers and opportunities are experienced with the organization of Mobility as a Service?

The main research question aims at explaining the factors for the intention to use Mobility as a Service for *Paleiskwartier* residents (*read 'ridesharing' instead of 'MaaS' for students, see 3.4.1*). The explanatory factors that are investigated in this research are based on the conceptual model and are focused on the *intention* to use MaaS (N.B. not the *interest)*, see Figure 5. It is not only investigated why people have an intention to use MaaS, but also what share of the Paleiskwartier residents actually have an intention to use MaaS. Experienced barriers and opportunities with the organization of the MaaS pilot are investigated. Answering the central research question, five sub research questions are answered (formulated in 3.2.1 – 3.2.5). For each sub research question, the reasons for asking and used method(s) are mentioned.

6.2 Which factors explain the intention to use MaaS (sub research question 1)?

Based on cluster analysis and ordinal logistic regression, it is concluded that the intention to use Mobility as a Service is mostly explained by attitudes of respondents towards MaaS. Socio-economic factors could not significantly explain the intention to use MaaS, for *Paleiskwartier* residents. Actual mode use could not significantly explain the intention to use MaaS in the ordinal logistic model but is used for traveller segmentation.

6.2.1 The intention to use MaaS explained

Explanatory variables that significantly explain the intention to use MaaS are depicted in Table 24. The higher an individual score on these statements (except for travel aspect 6: flexible traveling), the more likely an individual is to use Mobility as a Service. Each explanatory variable is related to a component of the conceptual model (see paragraph 2.7).

Explanatory variable	Component conceptual model and explanation
S:4 – 'New mobility concepts (e.g. BlaBla car or Uber) make me enthusiastic'	**Attitude:** the intrinsic motivation in new mobility concepts reveals the intention to use MaaS.
A:1 – Healthy travel	**Travel aspect:** importance of healthy travel reveals the intention to use MaaS, which indicates that the facet 'health' should be included in a MaaS travel advice
S:8 – 'I do not mind travelling with unknown persons'	**Attitude:** intended MaaS users do not mind travelling with unknowns, which is beneficial from the perspective of ridesharing

	(with unknowns), carsharing (not using an owned car) or transit (inherent to travelling with unknown persons)
S:6– 'I do sometimes look for alternatives for my own car'	**Attitude:** MaaS could be a solution for respondents' wish of looking for alternatives for the privately-owned car
S:3 – 'I do not need to possess a car, if travel alternatives would be (almost) everywhere and anytime available.'	**Attitude:** MaaS could be a solution for respondents' wish of seriously deliberate to sell their privately-owned car
A:6 – Flexible travelling	**Travel aspect:** travellers having a high importance of flexibility of travelling have a lower intention to use MaaS

Table 24 Independent variables that significantly contribute to the intention to use MaaS.

6.2.2 In-depth intentions to use MaaS

Sochor et al. (2015), Karlsson et al. (2016) and *Kennisinstituut voor Mobiliteitsbeleid* (2017) indicate that existing transit users tend to be the first potential users of Mobility as a Service, since this group is already familiar with multimodal travelling (not per se *integrated* multimodal travelling). However, as is concluded from the group interview held with 15 MaaS interested residents in the case study area, the added value of Mobility as a Service compared to separate shared mobility providers is not fully understood by this group, ex-ante the service is operational. Respondents indicate that they are already familiar using shared modes (e.g. the Greenwheels or OV-fiets) and indicate that they do not mind using two separate travel applications to book and pay these shared modes. It should be noted that the Dutch Railways could be seen as a preliminary MaaS integrator, having a travel planning application to book door-to-door mobility, but only for rail services (buses and trams are not included). Also, the Dutch Railways do not provide different trip options (e.g. sustainable or economy options) from A to B, which is the case for a 'true MaaS integrator' (Jittrapirom et al., 2017). Conclusions for the focus group interview are only valid for the *Paleiskwartier* sample and could not be extrapolated for the city of 's-Hertogenbosch or high urban areas in the Netherlands.

6.2.3 Differences with the literature on MaaS concerning explanatory factors for the intention to use MaaS

It is concluded that results of this research compared to other research on MaaS (i.e. Karlsson et al. (2017) and *Kennisinstituut voor Mobiliteitsbeleid* (2018)) differ on two important factors:
(1) the absence of the effect of age/education level on the level of interest to use Maas
(2) the absence of the effect of spatial configuration on the level of interest to use Maas

Concerning the first difference the lack of significant explanatory power of age and education level on the intention to use MaaS for *Paleiskwartier* residents could be ascribed to the fact that the sample is homogeneous in its composition concerning education level: 77.2 % of all respondents is high educated, compared to 30% for the average of the Netherlands (Compendium voor de Leefomgeving, 2017). Concerning the second difference, the effect of spatial configuration on the intention to use MaaS could not be investigated for the case study area, since the spatial configuration *within* the neighbourhood is consistent (a high urban environment within 1 km from an intercity station). The inverse relationship between 'flexible travelling' and intention to use MaaS is also against theoretical findings. One of the key characteristics is that MaaS fits to a flexible travel pattern, because of its multimodality. Research is needed to investigate if the questioning is unclear, or that this inverse relationship holds because of the preference of taking the car, which is a very flexible transport mode.

6.3 What traveller segmentation is of relevance, concerning the intention to use MaaS (sub research question 2)?

6.3.1 Traveller segmentation

It is concluded that approximately a fifth of the population is a potential MaaS user, based on the likeliness of using MaaS, attitudes towards MaaS related aspects and frequency of transit use. A large share of the population (clusters 2 and 4, i.e. 51.7%) is (very) unlikely to use Mobility as a Service. Approximately a third of the population is neither likely nor unlikely to use MaaS. Interestingly, this group has on one hand characteristics of typical MaaS users (i.e. multimodal travelling), but on the other hand not the socio-economic characteristics of typical MaaS users (i.e. high educated, young persons) and frequent use of travel planning applications. See Table 25. An important point of interest is the relative uniform composition of the *Paleiskwartier* sample in terms of education level, income level and societal participation. Higher levels of heterogeneity of these socio-economic variables might enrich the characterization of potential MaaS users in terms of socio-economic characteristics, such as age or education level. Therefore, the clusters derived in this research are only valid for the *Paleiskwartier* sample.

Cluster	Share	Component conceptual model and explanation
Cluster 1: 'Potential MaaS users' (3.8)	18.4%	**Attitudes:** positive attitudes towards MaaS related aspects. **Actual mode use:** very frequent users of train, infrequent use of car **Car possession:** lowest rate per capita (0.57 cars/cap.) **Socio-economic:** women overrepresented **ICT:** highest share of daily use of travel planning applications
Cluster 2: Frequent car drivers (1.9)	23.8%	**Attitudes:** negative attitudes towards MaaS related aspects. **Actual mode use:** very frequent users of car, infrequent use of train **Car possession:** highest rates (0.73 cars/cap.) **Socio-economic:** high income groups overrepresented **ICT:** *in*frequent users of travel planning applications
Cluster 3: Multimodal travellers (2.6)	29.9%	**Attitudes:** 'neutral' attitudes towards MaaS related aspects. **Actual mode use:** mixed use of train, bike and car for different trip purposes **Car possession:** intermediate rates (0.67 cars/cap.) **Socio-economic:** retired persons overrepresented **ICT:** highest share of non-use of travel planning applications
Cluster 4: Car lovers (1.8)	27.9%	**Attitudes:** negative attitudes towards MaaS related aspects. Claiming the importance of the freedom of the car. **Actual mode use:** mixed use of train, bike and car for different trip purposes **Car possession:** intermediate rates (0.67 cars/cap.) **Socio-economic:** retired persons overrepresented **ICT:** lowest share of daily use of travel planning applications

Table 25 Clusters and relation to conceptual model. In brackets below cluster name: interest to use MaaS (scale (1) very unlikely – (5) very likely).

6.3.2 Directions for further research on the intention to use MaaS

Concerning the conceptual model – see Figure 5 or Figure 19 – future research on explanatory factors for the intention to use MaaS could be directed to:

(1) the interaction between socio-economic characteristics and spatial configuration (i.e. residential self-selection) on the intention to use in MaaS

(2) differences in travel behavior, car possession and attitudes towards MaaS before, during after the operational phase of a MaaS application.

Direction 1: interaction effects socio-economic characteristics and spatial configuration on the intention to use MaaS

It could be investigated what the added value of MaaS compared to transit/private car is – in terms of its temporal accessibility – for residents living in different spatial configurations (e.g. urban versus rural). This is in line with the conclusions of the *Kennisinstituut voor Mobiliteitsbeleid* (2017), in which the intention to use MaaS depends on the residential location (i.e. a higher level of intention to use in high urban environments). Residential self-selection might be intertwined with the interest in MaaS (Cervero, 2002). Residential self-selection is about the interaction between spatial configuration and socio-economic characteristics: specific geographic contexts attract specific socio-economic groups (Cervero, 2002). For example, residents not owning a car prefer to live high urban areas where other transport possibilities – e.g. shared modes and transit – are widely available. The interaction between the spatial configuration and socio-economic characteristics might be an important contribution of the conceptual model (in which both factors are now evaluated separately).

An important drawback of the uniform population in the *Paleiskwartier* – in terms of education and income level – is that the influence of socio-economic characteristics on the intention to use MaaS could not be significantly proved. Regarding residential self-selection, the interest in MaaS for high urban residing residents could be higher than average, since MaaS fits to the travel mode interests of this group of people. On the other hand, the presence of transit, shared modes and closeness of facilities for high urban residents attenuates the contribution of MaaS for them. This assumption is based on the focus group interview, in which residents of the *Paleiskwartier* indicate that they are satisfied with their existing transport possibilities and that Mobility as a Service would not explicitly enrich their satisfaction rate.

Concerning the added value of MaaS in rural areas, Mobility as a Service could be an important contribution to demand responsive transport (DRT) in rural areas. In terms of temporal accessibility (Geurs & van Wee, 2004), the added value of MaaS is assumed to be greater in rural than in urban areas. This because rural areas are characterized by low accessibility rates of transit outside peak hours, compared to urban areas. In the rural context, MaaS could contribute to reduce the inequity in transport possibilities for non-car owning residents, compared to existing low levels of transit or long door-to-door travel times (Martens, 2018) (Geurs, et al., 2018). The added value of MaaS for accessibility does not solely hold for rural residents, but also for city residents having a destination in a rural context (e.g. visiting family). For example, focus group participants indicated that they would not use the MaaS application *within* the city (they use the bike) or *between* cities (they use the train), but solely to travel from and to rural areas, where the accessibility by transit is meagre.

In this research, differences and similarities in factors explaining the intention to use MaaS for different target groups (e.g. students, residents and employees) is not investigated. To best knowledge, no research has investigated the intention to use ridesharing by employees. The *Paleiskwartier* has a large group of employees and related traffic movements. Since 55% of the employees reach the neighbourhood by car (Brabants Mobiliteitsnetwerk, 2018), it is of relevance to investigate to what extent MaaS could reduce the modal split of the private car and thereby reduce the pressure on parking lots in the neighbourhood. Additionally, from the process perspective, it is of relevance to what extent companies are willing to participate in MaaS, and for what reasons.

Direction 2: differences in travel behavior, car possession and attitudes

When MaaS will be operational in the *Paleiskwartier*, changes in the factors explaining the intention to use MaaS could occur. These changes are the resultant of actual use of MaaS ('group B' in Figure 19) or people that stop using MaaS ('group A' in Figure 19). An investigation of these changes is of relevance to reveal:

- To what extent MaaS leads to a modal shift from private car to shared modes
- To what extent MaaS could lead to lower car possession rates
- To what extent MaaS could reduce the car parking pressure in the *Paleiskwartier*
- Why people stop using MaaS (i.e. attitudes, the perceived usefulness and ease of use)
- What motivations users have to keep on using MaaS (i.e. attitudes, the perceived usefulness and ease of use)

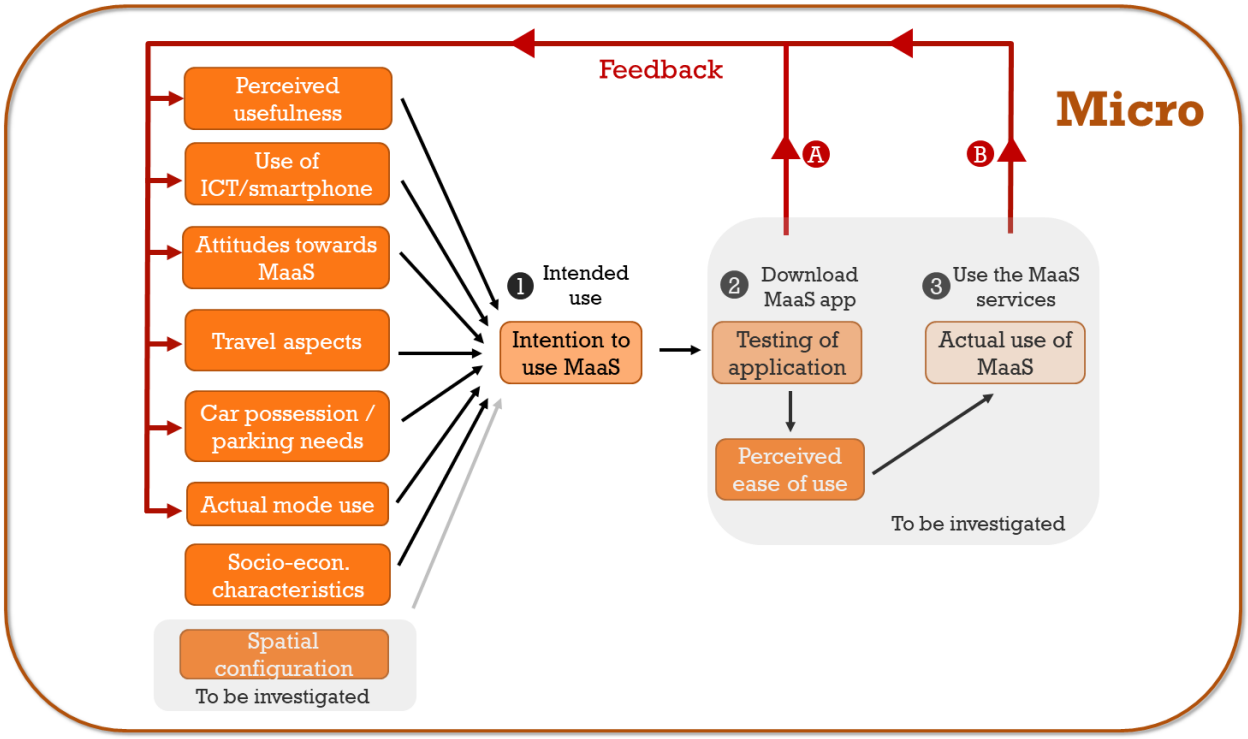


Figure 19 Conceptual model for future research on the micro level of the MaaS ecosystem.

Karlsson et al. (2016) have concluded that the UbiGo trial in Göthenborg have led to a significant reduction in the use of the private car (aspect 'frequency of mode use'), more positive attitudes towards shared modes and increased use of Mobility as a Service. Also, when MaaS is used on a daily basis, it could lead to reduced car possession rates and lower needs for parking spots (Karlsson et al., 2016). The latter effect is of relevance for the case study area, since 58% of the respondents indicate that they experiences (large) difficulties looking for a parking spot in their neighbourhood. It is not solely of relevance to investigate why users do *use* MaaS, but also why users *stop* using MaaS. If MaaS could contribute to positive externalities such as reduced car use or parking, it is of importance to attract and retain as much as possible users, thereby reaching societal goals. On the other hand, if it turns out that MaaS had adverse effects (e.g. the shift from transit to shared cars), then it should be investigated why this adverse effect occurs. If the group that stops using MaaS during a field trial turns out to be a significant share, it is of societal relevance to investigate which barriers this group experience during the use of MaaS.

6.4 The intention to use ridesharing by *Paleiskwartier* students (sub research question 3)

The intention to use ridesharing by *Paleiskwartier* students is mostly explained by practical benefits (i.e. avoiding the hassle of looking for a parking spot), social aspects (i.e. meeting new people) and the absence of a need to possess a car if travel alternatives will be available. Flexibility is related vice versa: the more important a respondent evaluates flexibility, the lower the intention to use ridesharing. In line with future directions for research on users of MaaS, differences in attitudes and travel behavior could be investigated when the ridesharing application is operational for the *Paleiskwartier* student population. Concerning the pressure on parking spots nearby the school, from a societal perspective it could be interesting to investigate if ridesharing could lead to higher vehicle occupancy rates and thereby a lowered need for parking spots. More specifically not only *how* ridesharing could lead to higher occupancy rates, but also *which mechanisms* (e.g. social or financial stimuli) could stimulate the use of ridesharing.

6.5 Expectations on the inclusion of societal goals in MaaS (sub research question 4)

The inclusion of societal goals in Mobility as a Service (MaaS level-4) is investigated for the case study area. Conclusions drawn in this section are only valid for the case study area and should not be extrapolated on the provincial or national level. The public transport authority – the province Noord-Brabant – emphasize that MaaS is meant to be provide tailor-made transportation for individual travel demands, rather than that MaaS is a translation of societal goals.

6.5.1 Which barriers are experienced concerning the inclusion of societal goals in MaaS?

Difficulties to include societal goals in MaaS could be explained by the following factors:

- **A lack of legitimacy:** the public transport authority has no legislative power to directly steer on behavior via a specific MaaS application. For example, the PTA indicates that it could not legally force MaaS integrators to include travel options aiming at a specific societal goal (e.g. low carbon travelling).
- **Difficulties to outweigh different societal goals:** the public transport authority has difficulties to include different, often incompatible, societal goals in Mobility as a Service. For example, using shared cars with MaaS creates a specific basic of shared/public transportation for rural residents, but might also compete with transit (i.e. lower occupancy rates)
- **Translation of societal goals into tangible travel advices:** the public transport authority foresees true doubts about the translation of different societal goals into tangible travel advices in a MaaS application. For example, it is unclear what the effect – e.g. in terms of CO_2 reduction or societal inclusion – of different (financial) incentives within a MaaS application is. Even when the translation is possible, it is still unclear if travel advices lead to desired effects (i.e. the adoption rate by users)

6.5.2 Future research on the inclusion of societal goals

Differences in public and private aims to include societal goals exist for the case study. Private MaaS integrators do not directly benefit from incorporating societal goals in their services. Integrators indicate that they predominantly have a customer-oriented focus. Private MaaS integrators "A" and "B" indicate that the costumers of their services are not very eager to directly implement 'government-steered' travel incentives, as long the individuals do not have a (direct) profit of acting a specific travel behavior. MaaS integrator "B" indicates that changes in travel behavior are revealed when both the government and user have profit of a certain supply of transport possibilities (e.g. nudging). Future research could focus on which mechanisms stimulate certain individuals to act a specific behavior (with the deeper aim of realizing societal goals). An example of such a mechanism could be gamification, which is the application of game strategies in a scientific context (Putz & Treiblmaier, 2015). It is wise to investigate what the exact effects – e.g. in terms of reduced greenhouse gases – of different steering mechanisms are on travel behavior. This in combination with different possibilities – in terms of money, time and duration – to nudge travellers with specific mode choices within the MaaS ecosystem.

6.6 Barriers and opportunities experienced during the process of setting up MaaS in the *Paleiskwartier* (sub research question 5)

The process of setting up the MaaS pilot for the case study area the *Paleiskwartier* is investigated in this research. One of the key aspects is the delay in the operational phase of the MaaS application designed by MaaS integrator "A": at the moment of writing, the MaaS application is still in development. Concerning the public-private collaboration, Karlsson et al. (2017a) conclude that barriers experienced with the organization of Mobility as a Service are mainly the lack of collaboration between public and private service providers and unclear role divisions between public and private parties (Karlsson et al, 2017a. pp. 7). Table 26 indicates which barriers are experienced by different public and private actors concerning the organization of MaaS for the pilot analysed in the research.

6.6.1 Experienced barriers

The private MaaS integrator "A" predominantly indicates that the lack of a level playing field between existing large private bus and rail companies and smaller private MaaS integrators. For example, the involved MaaS integrator "A" indicates that the unavailability of reduction fares of buses and trains and lack of real-time vehicle data is a clear sign of the absence of a level playing field. This barrier harms the private MaaS integrator to provide an affordable service to customers. This could be evaluated as an 'inter-organizational barrier' (Smith, et al., 2018a). An unclear role division is experienced by the public transport authority and the PTA aims at a more steering role towards the private MaaS integrator in the future. A more steering role from the PTA is required since the private MaaS integrator lacked in transparency in the process, concerning the communication with other commercial parties and the organization of MaaS.

Barrier	Experienced by	Open Innovation barrier
Lack of a level playing field for private MaaS integrators	MaaS integrator "A"	Inter-organizational barrier
Unclear role division	PTA	Organizational barrier
Lack of transparency in the process by the MaaS integrator	PTA	Inter-organizational barrier

Table 26 Barriers experienced by public and private actors in the MaaS ecosystem for the case study.

6.6.2 Experienced opportunities

Opportunities for a vital organization of MaaS are mentioned by private and public actors (see Table 27). In line with conclusions of Meurs et al. (2018), trust, commitment towards shared goals and openness in distribution of data and information are the most important opportunities to smoothen the operation of MaaS.

Opportunity	Added value
Trust	Trust among public-private and private-private actors in a MaaS ecosystem reduces delays in the process
Commitment towards shared goals	Speaking in 'the same language' is necessary to target MaaS for specific (societal) goals
Openness (in data and information)	Open available data and open information distribution creates a level playing field for private MaaS integrators and public transport companies

Table 27 Opportunities for a vital organization of MaaS, derived from interviews with involved private and public actors.

6.6.3 Directions for further research on opportunities and barriers

Conclusions presented in this section are based on interviews with solely two private MaaS integrators and one public transport authority, for the specific case the Paleiskwartier. Therefore, results could not be generalized for MaaS in general. In addition, these barriers and opportunities are only valid in the preparation phase of Mobility as a Service and might highly differ in the operational phase of MaaS in the future. Therefore, more case studies are needed to validate experienced opportunities and barriers. As been indicated by the involved actors, the opportunities are recognized, but the second step to concretize these opportunities is difficult. For a set of case studies, different possibilities – e.g. contracts, public-private collaborations – could be evaluated to realize these goals. In a similar manner, future research could focus on how the barriers experienced by public and private actors could be tempered, using different mechanism of forms of collaboration.

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