Mobility-as-a-Service
Miracle or Misfortune?

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Royal HaskoningDHV
Enhancing Society Together

TU Delft

Mobility-as-a-Service
Miracle or Misfortune?

Assessing the effects of monthly bundles on travel behavior change in the Netherlands with a combined stated adaptation and stated choice experiment

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Master thesis submitted to Delft University of Technology

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

In Complex Systems Engineering and Management

at

Faculty of Technology, Policy and Management

by

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To be defended in public on December the 5th, 2019

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PREFACE

Dear reader,

Before you lies my thesis in which I studied the impacts of Mobility-as-a-Service bundles on travel behavior change. With this thesis, I hope to obtain my Master's degree in Complex Systems Engineering & Management. When I started my bachelor Science & Innovation Management in Utrecht, I would have never thought to end up in Delft. However, I am very happy that this overwhelming journey brought me here. This journey now comes to an end. I look back on six incredible years being a student and I am grateful for everyone I met on the way.

The journey towards this final chapter in my studies has not been without challenges. Never before have I had to work on such a big project all by myself. MaaS being an ill-defined concept involved making a lot of decisions, which is something, to say the least, I am not very good at. This resulted in multiple moments that I was ready to completely start over. I am glad I didn't start over, because despite the hurdles, the end product is something I am proud off.

This would not have been possible without the help of many people. Therefore, I would like to thank all of you. Firstly, Eric, thank you so much for being my first supervisor. Without your adequate feedback I would have still been hopelessly lost. Secondly, Wijnand, thank you very much for helping me see the bigger picture, and a special thanks for sharing my survey. Thirdly, Wilco, thank you for giving me the opportunity to execute my research with Royal HaskoningDHV, your enthusiasm about my subject and all our coffee moments.

That being said I hope that you will enjoy this read.

Rein de Viet
Utrecht, November 2019

SUMMARY

1. Introduction

The growing urbanization and rising demand for mobility are increasingly putting pressure on the sustainability and livability of urban areas will worldwide. Private car-use plays a significant role in causing these negative external effects in the form of emissions and congestion. Investments in infrastructure alone will not be sufficient to reduce congestion. Moreover, technical improvements are not sufficient to reduce emissions enough to reach environmental goals. If cities are to remain accessible and livable, radical changes of the transport system and structural behavioral changes of its users are necessary. Public transport is the most efficient way of transport. A problem with public transport however is that can usually not offer door-to-door transport. Multiple modes therefore have to be used in a single journey, which takes extra effort on the travelers part which. A policy goal has therefore been to make multi-modal travel more seamless, in order to make sustainable transport more attractive.

Mobility-as-a-Service (MaaS) is a new concept that is expected to address this issue. The idea behind MaaS is to shift the transport system from an asset-centric system towards a service-centric system. By integrating a variety of different transport modes on one platform, users are enabled to seamlessly plan, book and pay for their total mobility demand. Traditionally users of public need different tickets, different mobile applications and different payment methods for each operator when travelling with a variety of transport modes. With MaaS, no different subscriptions or payment methods are necessary to use multiple transport services. Two different tariff options are available of getting access to MaaS; pay-as-you-go and monthly bundles. In the former, the user pays for his or her effective use, and with the latter, access to a combination of multiple mobility services, usually at a discount, is bought much like monthly mobile phone contracts. Bundles are expected to provide the freedom of a car without owning

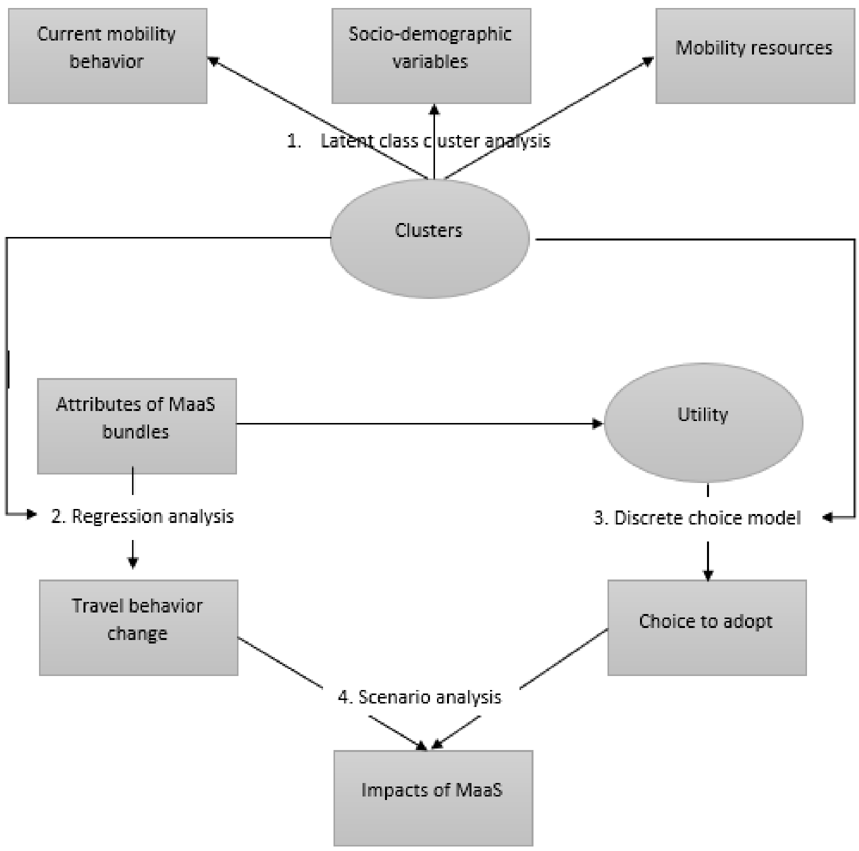
The hopes of MaaS are that due to the simplicity of the service, and the plethora of alternatives being offered, the need to own a car decreases. As car use starts from car ownership and public transport is regarded as the backbone of MaaS more sustainable travel should be promoted. The expected positive impacts that are being attributed to the implementation of MaaS are however not self-evident. There is little empirical evidence available that confirms or refutes this hope. Moreover, no studies have been performed in the Dutch context. Therefore, this study aims to answer the following research question, by answering the sub questions found below:

What are the effects of Mobility-as-a-Service bundles on the travel behavior of different travelers in the Netherlands, and how do these effects relate to public policy goals?

1. *Which types of travelers can be identified based on their current travel pattern, and what are their characteristics?*
2. *What are the effects of bundle elements on travel behavior change of the different identified travelers in the Netherlands?*
3. *What are the effects of bundle elements on the willingness to adopt MaaS for the different identified travelers in the Netherlands?*
4. *How can bundles be constructed in order to align their impacts with public policy goals, and what are the corresponding effects of these bundle configurations?*

2. Methodology

These impacts depend both on the degree of adoption of MaaS, as well as on how users will effectively change their travel behavior. In this research, a survey was therefore constructed in which both aspects were measured. This was done by means of integrating two experiments into one, namely a stated adaptation experiment, and a stated choice experiment. In this combined experiment, respondents were shown four experimentally varied bundle configurations, that are part of an experimental design with 16 choice sets. The bundle configurations differed on 6 variables namely: amount of access to: train, bus/tram/metro, shared cars, shared bikes and taxi. These variables were chosen based on a desk research towards MaaS bundles. For every bundle design, respondents were first asked to indicate how they would change their travel behavior. This was done by telling the respondents to imagine they would possess the bundle without costs, for instance because they received it from their employer. This way travel behavior change would more closely resemble real life choices in the way of bundle possession. Travel behavior was measured on four levels: change in mode use, total trip frequency, peak-hour avoidance and car-shedding. Then, the price was introduced, after which the respondents were asked if they were willing to adopt the bundle for that price themselves. This way market shares could be estimated. Also a questionnaire was included to measure socio-demographic variables and current travel behavior of the respondents. This information was used to cluster the respondents based on their current travel behavior, which was used to explore differences between different types of travelers. 203 respondents completed the survey. The analysis methods are shown in the figure below. The results will be presented based on the order as shown in the figure.



3. Results

3.1 LCA

First respondents were clustered by means of Latent Class Analysis in homogeneous groups with regards to their travel behavior. Five different types of travelers were distinguished. These were the PT + bike group; the car mostly user group; the Bike + car group, the PT + car group; and the multi-modal innovative group. The PT + bike group was the largest with 33,6% of the sample. The car mostly group contributed to 21,8% of the sample. The bike + car group constituted of 18,2% of the sample. And the PT + car group 16%. Multimodal innovative users were the smallest group, consisting of 10,4% of the sample.

The found clusters found in the present study show similarities between research executed by Molin, Mokhtarian, & Kroesen (2016) in which also a LCA of travel behavior was executed on a sample of the Dutch population. However, in that study, no shared mode were included, and therefore the distributions of the clusters might be somewhat different. Nonetheless, when comparing the result it was found that in this research more public transport users are present, and therefore the results might be more skewed towards the public transport user view on the topic.

3.2 Regression analysis: Mode use

In the first part of the results the effects of bundle elements on travel behavior change are discussed. It was found that changes in mode use are most strongly affected by the train bundle attributes. Bundles with more inclusive access to train have the strongest positive effect on both train and BTM use. This shows the complementarity of train and BTM. Car use on the other hand decreases mostly with an increasing level of access to trains. The BTM attribute has a positive effect on BTM use, and a negative effect on car use. Cheaper access to shared cars in the bundle has a positive influence on shared car use, and a negative influence on private car use. In terms of strength of the effects, the train attribute has the strongest influence on decreasing car use, second in line the BTM attribute, and last the shared car attribute. These results show that public transport provides the backbone of MaaS, and plays the most important role in decreasing car-use. Car trips would only be partially be replaced by shared car trips. The shared bike attribute increases shared bike use to a larger extent than the decrease in private bike use, and therefore it can be concluded that the inclusion of shared bikes lead to an increase in active mode use, rather than a mere substitution of mode. An increasing number of taxi trips on the other hand decrease the use of shared bikes. They however increase the use of train, besides of course the increase in taxi use. This shows that taxi trips are a valuable addition to bundles because of their potential to increase train travel, and thereby probably provide as a substitute to car use, but on the other hand they lead to less use of shared bikes. There are thus conflicting interests in the configuration of bundles.

3.3 Regression analysis: cluster differences mode use

It was found that bundle elements affect the change in mode use of different types of travelers in different ways. Generally, it was found that having more experience with a mode lead to an higher willingness to increase mode use. Less experience with certain modes thus leads to a lower willingness to increase their usage. For example, strict car users, and bike + car users were found to be least likely to increase their train use as a result of more inclusive access to trains with MaaS bundles. The PT + car users were most likely to increase their train use, followed by the PT + bike cluster. Interesting results were found for strict car users and BTM. This group showed to be most willing to increase their

BTM use when unlimited access to BTM is granted, even though they have little experience with it. Also their car use would decrease mostly as a result of unlimited access to BTM in the MaaS bundle. It thus seems that strict car users see BTM as a valuable component of MaaS. Looking at car use, it was found that people who use both car and other modes (PT + car and car + bike) are willing to decrease car use most strongly when having unlimited access to train in their bundle. Taxi use would be increased most by the PT + bike and the PT + car cluster. It thus seems that taxi is seen mostly as an addition to PT, and it is questionable whether or not the addition of taxi trips leads to a reduction in car trips. Another interesting finding was that shared car use would be increased mostly by the people in the clusters that currently use cars least often. This thus indicates that overall vehicle use might be induced.

3.4 Regression analysis: total trip frequency

When looking at total trip frequency, it was found that it is increasing when unlimited access to public transport was offered in the bundle. Besides having a negative effect on car use, these bundle attributes thus also mean that accessibility of people is increased, and therefore more trips are made than would have been done otherwise. Differences were observed for the different types of travelers. Especially current public transport users, but also bike + car users were found to increase their total trips made most strongly as a result of these bundle attributes. This could mean that these groups have some latent desire for travel that could be fulfilled by MaaS bundles including these attributes. Car mostly users were least affected by these attributes, which could mean that they don't have a latent desire for extra travel. They are also the only group that would reduce their amount of travel when lower train bundle attributes are provided to them in comparison to unlimited access.

3.5 Regression analysis: peak-hour avoidance

Peak hour travelling was found to be affected only by the train bundle attribute level: free off-peak + weekend, and weekend free + off-peak discount. The effects are however limited to cluster 1: the PT + bike users. It thus seems that this is the only group that is flexible in their departure time choice. They are however the largest user group of train travel, thus when they increase their train travel mostly off-peak, the effects of increased train travel could be much better handled than when it all would be increased in peak hours.

3.6 Regression analysis: MaaS as alternative for car-ownership

When it comes to car-shedding, no results were found between bundle attributes, and the decision to get rid of a car for car-owners. It thus seems that MaaS bundles currently do not provide enough value for car owners to get rid of their car. For non-car owners, it was found that the unlimited rail attribute has a positive influence on the decision not to buy a car in the future. This would thus mean MaaS bundles with unlimited access to rail can be seen as an alternative to car-ownership for non-car owners.

3.7 Discrete choice modelling: adoption of bundles

The results of the discrete choice model revealed that a base disutility was present for MaaS, meaning that when all attribute levels are set to 0, (hence also costing 0 euro), people would experience a disutility from MaaS. This implies that people generally prefer to stay with the status quo. MaaS adoption was found to be most strongly influenced by unlimited train travel as an attribute. Free off-peak travelling by train was second most preferred bundle attribute. After that, shared cars are seen as an important bundle attribute to adopt MaaS. The inclusion of unlimited access to BTM, shared bikes, and free taxi trips do not significantly increase the willingness to adopt MaaS. Price of the bundle, as expected, has a large negative effect on the degree of adoption.

3.8 Discrete choice modelling: cluster differences adoption

Different clusters were found to have different preferences regarding MaaS bundles. The PT + bike user group was found to have the lowest base disutility associated with MaaS, and are thus most likely to adopt MaaS. They attain the highest preference to the train attributes, but they are most price sensitive. Cluster 4 is the second most likely candidate for MaaS adoption. This is the PT + car group. They also value the train attribute most highly, but attain a higher value to shared car compared to cluster 1. This group is a little less price sensitive. Cluster 2, the car mostly group, is least price sensitive, and values the inclusion of shared cars and BTM more compared to the other clusters. Train is less important for them. Cluster 3, the bike + car users, attain a negative utility to the inclusion of shared cars, do not value the inclusion of train as high as other groups, and are very price sensitive. They are thus not ideal MaaS adopters either. It can thus be concluded that especially public transport users receive a net increase in utility from adopting MaaS, over not adopting MaaS, which is mostly dependent on the access to public transport.

3.9 Scenario analysis: bundle configurations

The estimated models were applied for different bundle configurations to show the effects of travel behavior change of users, the willingness to adopt, and the absolute effects on travel behavior. This was first done with the models based on the entire dataset, and then with the models based on each cluster specifically. Four different bundle configurations were tested: the minimum bundle (with all attribute levels set to the minimum), the maximum bundle (which happened to have the same configuration as the bundle aimed at minimizing car use, and maximizing shared car use) a bundle aimed at maximizing shared bike use, and a bundle aimed at maximizing peak-hour avoidance.

It was found that with the minimum bundle, shared bike use would be increased, but very limited effects were found on the other modes. The max bundle was found to have most strong effects on travel behavior in general. Mode use for all modes would go up vastly, at the expense of car-use. However, also other car based modalities (taxi and shared cars) would be increase substantially. When shared bike use was aimed to maximize with the bundle configuration, effects on travel behavior were more limited with regards to decreased car-use, and increased shared car use. Shared bike use, and train use would still be increased substantially however. Finally, the bundle that is aimed at maximizing off-peak travelling was found to have a smaller effect on the increase in train travel, but still quite a large effect on the decrease in car use. Also shared modes and BTM would be increased. According to the MNL model, adoption rates could be as high as 50% for MaaS.

When applying the models for the different clusters, differences with regards to the travel behavior change and adoption levels could be observed. This also made it possible to get an estimate of the absolute changes in travel behavior, by knowing the current travel behavior of the clusters. It was found that frequent car users are among the least likely adopters of the different bundles. Absolute changes in decrease in car-use are therefore limited. Current public transport users are more likely to be adopters of MaaS. This group would however increase unsustainable travel behavior, such as increasing shared car and taxi use. Therefore, absolute changes in reducing negative side effects of transport are very small, if not counterproductive.

4. Conclusion

Taken together, the findings of this research suggest that the expected effects of MaaS bundles on improving sustainability and reducing congestion will be very limited, if not contradictory. This is due to the fact that MaaS propositions as they were proposed in this research are not interesting enough for car-users, hence reduced car use will be limited. The bundles would however rather spark interest with current public transport users. Nevertheless, the travel behavior of these people would likely become less sustainable, as MaaS would lead to an increased use of car-based modalities such as shared-cars and taxi.

The findings of this study provide insight for an active governance role for governments wishing to steer MaaS in a more desirable way. Based on the results in this study, achieving a better alignment between the impacts of MaaS and public policy goals can be achieved in two ways. First of all, MaaS adoption should be made more attractive for current car-users. Secondly, the unintended consequences of public transport users shifting towards more car-based modalities needs to be prevented. Recommendations are provided for stimulating adoption by car-owners, and reducing side effects by instigating a dynamic pricing regime.

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1. INTRODUCTION

In this chapter, the research problem and objective will be introduced. In section 1.1 relevant background information will be provided. This results in a problem statement which is defined in section 1.2. In section 1.3 the research objective is introduced, by giving a summary of the identified knowledge gap and stating the research question aimed to solve this knowledge gap. In section 1.4 a short overview of the research approach is given. After that, the relevance of this research is discussed in section 1.5, and finally an outline of the rest of the thesis is provided in section 1.6.

1.1 BACKGROUND

The growing urbanization and rising demand for mobility increasingly puts pressure on the sustainability and livability of urban areas will worldwide. Private car-use plays a significant role in causing these negative external effects in the form of emissions and congestion (Çolak, Lima, & González, 2016; van Wee, Maat, & De Bont, 2012). In 2017, nearly a quarter of all carbon dioxide (Co2) emissions in Europe were caused by personal road transport; a substantial share that is furthermore found to be increasing (IEA, 2017). Additionally, the increase in travel time due to congestion results in economic losses, which were estimated to be between €2,8 and €3,7 billion in the Netherlands in 2017. Prospects for 2023 are that time losses due to congestion will increase with 35% (KiM, 2017).

As shown by the National Market an Capacity Analysis 2017 (NCMA), investments in infrastructure alone will not be sufficient to reduce congestion in the Netherlands (Ministerie van Infrastructuur en Milieu, 2017). Moreover, it is increasingly stipulated that technical improvements are not sufficient to reduce emissions enough to reach environmental goals (Banister, 2008). If cities are to remain accessible and livable, radical changes of the transport system and structural behavioral changes of its users are necessary (Anable, Lane, & Kelay, 2006). Even though there is a widespread consensus about these issues, effective individual change is hardly accomplished by itself. Consequently, policy makers are eager to stimulate innovation and policy that lead to citizens changing their behavior towards more efficient and sustainable means of transport.

Public transport is currently the most efficient way of (urban) transport. A tram can transport as many as 11 times the amount of people per hour on a certain trajectory in comparison to a continuous flow of cars. For metro systems this can even amount up to 400 times as many people (Hilmola, 2011). Besides this efficiency in terms of space, public transport is also much more efficient in terms of energy use. The average fuel consumption is about 22 times lower per passenger km when taking the metro instead of the car (Kalenoja, 1996). A problem with public transport however is that it can usually not offer door-to-door transport, referred to as the first and last-mile problem. Multiple modes therefore have to be used in a single journey, which requires extra 'effort' on the part of the traveler (Stradling, 2011) . On the contrary, cars can usually cover the entire length of the journey. This has resulted in a society that is largely car-dependent (van Acker, van Wee, & Witlox, 2010). A major public policy goal for improving sustainable transport has therefore been to make multi-modal transport more seamless, so that car dependency decreases.

A recent emerging concept that is thought to contribute to this public policy goal is Mobility-as-a-Service, hereafter referred to as MaaS (Ambrosino, Nelson, Boero, & Pettinelli, 2016). The idea behind MaaS is to shift the transport system from an asset-centric system towards a service-centric system. As-a-service concepts are gaining in popularity in various different markets such as entertainment (e.g. Netflix and Spotify) and are fueled by trends such as the digitalization and evolving sharing economy which are changing people's values and habits (Caiati, Rasouli, & Timmermans, 2019). The transport sector is increasingly affected by these trends. Traditionally users of public need different tickets, different mobile applications and different payment methods for each operator when travelling with a variety of transport modes. The fragmented nature of these different services results in extra effort on the traveler's part when using them. The prospect of MaaS is to integrate the entire spectrum of different transport modes (both public, private and shared) on a platform, accessible on demand for the customer. Through this digital interface, users are enabled to seamlessly plan, manage and personalize their total mobility demand (Hietanen, 2014). Two different payment options are available of getting access to MaaS; pay-as-you-go and monthly bundles. In the former, the user pays for their effective use, and with the latter, access to a combination of multiple mobility services, usually at a discount, is bought much like monthly mobile phone contracts.

The hopes of MaaS are that due to the simplicity of the service, and the plethora of alternatives being offered, multi-modal door-to-door travel is made more seamless. Interest in monthly bundles is especially high since it is believed that they can function as an alternative to car-ownership, and can be used as a mobility management tool (Kamargianni, Matyas, Li, Muscat, & Yfantis, 2018). As car use starts from car ownership and public transport is regarded as the backbone of MaaS more sustainable travel should be promoted (Lund, Kerttu, & Koglin, 2017). Next to that, on the operator side, more efficient use of existing services should be accomplished by using MaaS as a smart mobility management system. Due to better integration of data, the MaaS operator can propose the ideal combination of transport modes to users for each trip by knowing the network conditions in real time while taking into account the user preferences (Kamargianni & Matyas, 2017). All in all, MaaS may thus have a lot of potential in contributing to societies grand challenges. Given the mobility challenges urban areas are facing, it is no surprise that public authorities see MaaS as a tempting development (Giesecke, Surakka, & Hakonen, 2016).

1.2 Problem statement

The expected positive impacts that are being attributed to the implementation of MaaS are however not self-evident. A growing body of literature points out that implementation might even have adverse effects if not governed correctly (Mulley, 2017; Pangbourne, Stead, Mladenović, & Milakis, 2018). As there is much money to be made in the MaaS business, many private companies will expectedly enter into the market. Little profit will however be made from the sale of public transport tickets (Li & Voege, 2017). Most likely, the real profit will come from usage of third party on-demand services (Alonso González et al., 2018). On-demand services such as car-sharing and ride-sourcing are however not likely to reduce congestion and improve sustainability due to their car-like nature. If current public transport users for example switch on a large scale towards such on-demand services, MaaS may in fact induce vehicle kilometers travelled.

Negative effects of some on-demand services are already being seen in practice. Since the introduction of ride-hailing service provider Uber in 2009, transit ridership has gone down with an average of 6% in major cities in the United States (Hall, Price, & Palsson, 2017). Especially after the introduction of the second ride-hailing service provider Lyft, price competition resulted in an ever larger pull away from public transport (Sadowsky & Nelson, 2017). Clewlow & Mishra (2017) found that 61% of all ride-sourcing trips would not have been made at all, by walking, biking or by transit, indicating that the introduction of these services may have led to an increase in vehicle kilometers traveled. Furthermore, in Helsinki the modal share of taxi increased after MaaS app Whim was introduced, due to the situation that a minimum of two taxi trips per month were included in the cheapest bundle, which users could not transfer to the next month (ITS International, 2018).

Yet MaaS bundles have also proven to possess the potential to influence travel behavior in a more sustainable way. In Gothenburg, Sweden, a MaaS pilot 'UbiGo' was held and two thirds of the respondents indicated that UbiGo encouraged to make more use of alternative modes of transport, in particular car sharing, buses and trams, as opposed to private vehicles (Sochor, Strömberg, & Karlsson, 2014). These effects are substantiated by a recent stated preference study that found a higher willingness of travelers to choose for shared modes if these were included in their MaaS bundle, indicating that MaaS may be used as to raise awareness about alternative modes of travel, and hence potentially as a mobility management tool (Matyas & Kamargianni, 2018).

1.3 RESEARCH OBJECTIVE

Given this background, it can be seen that MaaS bundles have the potential to contribute to a sustainable and efficient transport system, while at the same time there are signs that it may do the opposite. The alignment of the impacts of MaaS and public policy goals is thus far from self-evident and depend both on the degree of adoption of MaaS, as well as on how users will effectively change their travel behavior (Giesecke et al., 2016). The degree of adoption and the direction of mode changes as a result of MaaS bundles depend on how MaaS is offered to the users (i.e. which modes are included at what price etc.), which in term is influenced by how MaaS is governed.

Due to the fact that MaaS has not been implemented on a large scale yet, little empirical evidence is available that supports the effectiveness of MaaS on reaching its attributed goals. Additionally, rather few scientific studies are available that studied effects of MaaS in experimental settings. However, no studies to date exist that focus on the Dutch context. Therefore, the extent and direction of travel behavior change of potential MaaS users in the Netherlands remains uncertain. Consequently, the high expectations about the positive impacts with regards to sustainable and efficient travel as a result of MaaS rely on little empirical evidence (An extensive literature review leading to this knowledge gap can be found in chapter 2)

Given this uncertainty, it becomes clear that there is a need for thorough analysis of potential effects of MaaS bundles in the Netherlands in order to get a more realistic understanding of the potential of MaaS to contribute to societies grand challenges. To address the previously addressed knowledge gap, this research aims to find answer to the research question:

What are the effects of Mobility-as-a-Service bundles on the travel behavior of different travelers in the Netherlands, and how do these effects relate to public policy goals?

1.4 APPROACH

The first step in answering the research question, is to provide an extensive literature review towards the impacts of MaaS bundles on travel behavior change. In this review MaaS is defined and the (potential) impacts of MaaS bundles on changing travel behavior are studied. This step leads to the measurement levels to determine travel behavior change.

The second step is to explore how MaaS bundles might be offered to end users in the Netherlands (i.e. which modalities might be included, at what price and under which circumstances etc.). At the time of writing, there are no companies offering MaaS bundles in the Netherlands, and also worldwide there are rather few examples of MaaS bundles. Therefore, the elements of the bundles are not yet solidified. Furthermore, the construction of bundles is largely context dependent. For example, it does not make sense to include one-way car sharing in a bundle if there are no companies in the area offering this service. Therefore, first the concept of bundles are studied by means of an extensive desk research. An overview existing MaaS bundles from practice, and examples of how MaaS bundles are constructed in other scientific research, is provided. These results will be evaluated in order to give an overview of the elements of MaaS bundles and how they may be varied.

These bundle elements are then placed in Dutch context. In order to do this, the different transport services offered in the area will be examined. Furthermore the transport demand will be analyzed. The outcomes of this step are the attributes and attribute levels of MaaS bundles as they might be included in a future MaaS proposition in the Netherlands.

After these first two steps are finished, the empirical data will be gathered. The aim of this step is to analyze and predict changes in the travel behavior of possible users. Travel behavior manifests itself in choice behavior on two levels: choices to adopt MaaS bundles, and choices on how to change current mobility behavior. In order to determine the impacts of MaaS bundles, three different types of data thus have to be gathered: current mobility behavior of potential users, changes in travel behavior as a result of MaaS bundles, and willingness to adopt MaaS bundles.

Stated preference experiments are commonly used to collect choice data of hypothetical alternatives. Stated adaptation experiments are a suitable method to explore behavioral adaptations as a result of an external influence. In this research, an attempt will be made to integrate both experiments in one experiment, so that it becomes clear, who and under what circumstances will adopt MaaS bundles, and to what degree potential users will change their travel behavior.

Combined, these three insights can be used provide a comprehensive overview of the effects of MaaS bundles. The following sub questions are proposed to answer the main research question.

1. Which types of travelers can be identified based on their current travel pattern, and what are their characteristics?
2. What are the effects of bundle elements on travel behavior change of the different identified travelers in the Netherlands?
3. What are the effects of bundle elements on the willingness to adopt MaaS for the different identified travelers in the Netherlands?
4. How can bundles be constructed in order to align their impacts with public policy goals, and what are the corresponding effects of these bundle configurations?

1.5 RELEVANCE

This section elaborates on the contribution of this research. It is divided into three parts, scientific, practical and social contribution.

1.5.1 Scientific relevance

The outcomes of this research contribute the growing academic body of knowledge surrounding MaaS. First of all there is little empirical evidence about the impacts of MaaS on travel behavior change. This research contributes to this lack of knowledge by providing empirical data of the Dutch context. Furthermore, this research has methodological relevance. To the best of the author's knowledge, no integrated stated- adaptation/-choice experiment towards MaaS bundles exists that simultaneously addresses user preferences, and impacts on travel behavior change.

1.5.2 Practical relevance

This report is written for Royal HaskoningDHV. Insights gained in this research can aid the company in multiple ways. First of all the report will be distributed among colleagues working with MaaS in order to gain up to date knowledge about the subject. Results will also be presented for the business line.

The insights from this research can be helpful in their daily work with assisting clients (e.g. local governments) with the transition towards MaaS. The results could for example be useful in the evaluation of plans and policy options by better understanding the influences they might have on travel behavior change. Moreover, the outcomes of this research can be interesting for parties that aim to offer MaaS bundles. It could provide an understanding to what types of MaaS bundles might be appealing for potential users, and which types of bundles have positive effects attributed to them.

1.5.3 Social relevance

The outcomes of this research can also be relevant for society. A difficult issue with innovations of this kind is that their consequences are not easily predicted before they are fully embedded in society. However, changing possible unintended consequences of an innovation is very difficult once they are fully embedded in society. This research aims to gain insight in possible unintended consequences before the innovation is fully embedded. By doing so, policy makers can envision possible steering measures in order to align the impacts with public policy goals.

1.6 SCOPE

The effects examined in this thesis are limited to impacts of potential users. Wider effects such as on land use, and sustainability are seen as merely a consequence of the changing behavior of individuals, and are thus not focused on. The scope of this thesis is inside the Netherlands. The assumption is made to examine the effects of MaaS under the scenario that MaaS is fully realized and scaled up on a national level. This implies that shared concepts are largely available, making trips fully seamless. Only currently existing mobility services will be included in the empirical analysis, in order to not exhaust the respondents too much with envisioning how they would change their behavior in the future.

1.7 COSEM PERSPECTIVE

This research is executed in partial fulfillment of the requirements to obtain the master’s degree in Complex Systems Engineering & Management (CoSEM), at Delft University of Technology. In this master’s program, the design and effects of innovations in complex socio-technical environments are explored. MaaS fits well within the CoSEM domain, as it is an innovation that might have an extensive impact on users of the entire ecosystem. This research studies the influence of the design of the innovation on potential effects of the implementation of MaaS.

1.8 THESIS OUTLINE

This thesis is structured as follows: in the Chapter 2, an extensive literature review towards MaaS bundles is executed. This leads to the formulation of the knowledge gap, and the identification of the factors to be examined in this research. Then, in Chapter 3, the methodology is introduced. In Chapter 4, a desk research is performed towards MaaS bundles which are placed in the Dutch context. In chapter 5, the survey is designed. In Chapter 6 the results of the survey are presented. In chapter 8, a discussion, conclusion and recommendations are given.

2 MaaS bundles and their impacts on travel behavior

This chapter will provide, by means of a literature review, a comprehensive overview of the influences of MaaS on travel behavior. In section 2.1 the core concepts of MaaS are discussed. In section 2.2, the concepts of bundling are discussed. Then in section 2.3, the literature will be reviewed. This leads to the formulation of the knowledge gap in section 2.4, and identifies the potential impacts on travel behavior to be analyzed in this research.

2.1 What is MaaS?

Mobility as a Service first appeared in the academic spotlights in 2014 with the foundation of MaaS Global by Hietanen (2014). He described MaaS as "a mobility distribution model that deliver users' transport needs through a single interface of a service provider". Since then, interest in the concept has grown substantially. Several MaaS schemes/pilots have been implemented around the world, and an increasing (academic) body of literature surrounding the concept is emerging. At of the time of writing, there is no clear cur definition of MaaS however. Jittrapirom et al., (2017) reviewed all literature attempting to define Maas in order to compose a list of core concepts that MaaS entails. A list of nine concepts resulted from the review, which are presented here without hierarchical order:

1. Integration of transport modes: MaaS brings together multiple transport modes and allows users to choose any combination of transport modes in their multi-modal trips.
2. Tariff option: There are two types of tariff options are available. "pay-as-you-go" or "mobility bundles". With pay-as-you-go users are charged for the effective use and with bundles users buy a certain amount of km's/minutes/points for a monthly charge much like phone contracts.
3. One platform: Users of MaaS can plan, book, pay, and receive real-time information through a digital platform (mobile app or webpage).
4. Multiple actors: The ecosystem of actors is composed of mobility demanders, transport providers, platform owners, and other actors such as local authorities.
5. Use of technologies: MaaS is based on different technologies, such as smartphones, GPS, mobile internet, e-payment and database management.
6. Demand orientation: MaaS is a user centered paradigm, and seeks to offer transport services that are suited to the needs of the traveler.
7. Registration requirement: The user subscribes with an account for either a single individual or, in certain cases, an entire household. The subscription enables the use of the services and facilitates the service personalization.
8. Personalization: MaaS provides the end-user with specific recommendations and tailor-made solutions on the basis of her/his profile, expressed preferences, and past behaviors.
9. Customization: MaaS is customized to each user, so that they can modify the offered service option to their preferences.

2.1.1 Levels of integration

(Sochor, Arby, Karlsson, & Sarasini, 2017) further shed light on the concept of MaaS by making a useful distinction between levels of integration in order to understand potential effects of different MaaS services. The paper proposes a topology of four levels of integration being: (0) no integration; (1) integration of information; (2) integration of booking and payment; (3) integration of the service offer, including contracts and responsibilities; (4) integration of societal goals.

- Level 0: This level, being no integration, is seen as a reference situation. It must be noted however that in the Netherlands, integration has already been a target for public transport for a while now, with the OV chipcard being an example of integrated payment for different public transport modes.
- Level 1: In this level, multi-modal travel information of all modalities is integrated in such a way that level 1 providers support users find the best way to execute a trip, by suggesting a multitude of transport modes. This makes opting for alternative transport modes easier by simply making people aware of the alternatives available for making trips.
- Level 2: This level of integration is an extension of level 1, by adding booking and payment to the travel planner. This makes it easier for users to use alternative transport modes such as car-sharing, by only having to register to the level 2 operator, rather than to all transport operators separately.
- Level 3: Level 3 operators offer users monthly subscription packages, consisting of bundled offerings of mobility services, that aim to cover the total mobility demand of the users, so that it becomes a viable alternative to car ownership. The major difference between level 2 is that the operator now also takes responsibility for the transport service delivered to their customers.
- Level 4: This level can be an extension of the any other level by making it possible to integrate societal goals by setting the conditions for operators such that they will create incentives for desired behavior of the users. For example, by steering people towards public transport, or creating incentives for travelling off-peak.

In this research the nine core concepts as defined by (Jittrapirom et al., 2017) together with a minimum level three integration as suggested by (Sochor et al., 2017) is used to classify what constitutes MaaS.

2.1.2 The prerequisites and benefits of MaaS for users

If MaaS is to become an interesting alternative, there are a number of prerequisites that the service has to attain to. Durand & Harms (2018) showed that first of all, the service has to provide the user with autonomy. This refers to not being dependable on others when making decisions. Autonomy relates to a large degree on the second prerequisite, which is availability. Both in time and place, the service has to be available for users to be an interesting alternative. If for instance they want to travel with a shared car, but none are available in the area, the user is not autonomous is his or her decision to travel the way he or she wants. Thirdly, reliability plays an important role. The concept of reliability is changing in the context of MaaS however. For instance with the use of collective demand responsive transport, reliability of the pick-up time is something that users want to have, and is also shown they want to pay extra for. Finally, flexibility is an vital prerequisite. Flexibility means that users can change their behavior if for whatever reason they want to. Users should be able to

Next to prerequisites, using MaaS has to offer users enough benefit compared to the status quo before they are willing to adopt it. There are four advantages associated with MaaS. These are: cost, convenience, freedom of choice and customization (Durand & Harms, 2018).

Probably the most important reason to use MaaS is cost savings. It should be cheaper to own a MaaS bundle than to pay for all items included in them separately. Also, cost savings compared to owning a private car have to exists in order to be competitive. It has frequently be noted however that showing the costs savings of MaaS compared to private car is difficult to achieve because people drastically underestimate the costs of their car. The ownership of a vehicle brings considerable fixed costs, such as purchase costs, depreciation, maintenance, taxes and insurance. However, the variable costs are relatively low. It is mostly the variable costs that users take into account when comparing alternative. The fixed costs are taken for granted.

Secondly, convenience is another important benefit. Rather than having to locate, book and pay for each mode of transportation separately, MaaS lets users plan and book door-to-door mobility using just one app. Thirdly, choice freedom plays a central role in MaaS' benefits. Due to the large variety of offered transport modes, the best mode can be selected for each trip. Finally, customization to personal preferences is crucial for a successful MaaS proposition. Collaborative customization is the process in which customers can state their preferences, after which MaaS providers can offer a customized product. This not only beneficial for users, but also for transport providers.

2.2 MaaS Bundles

As was stated in chapter 2, bundles are the concept of interest in the study towards MaaS' effects, because they have the potential to change travel behavior, and reduce the need for vehicle ownership (Maria Kamargianni, Li, Matyas, & Schäfer, 2016). Bundling entails the sale of two or more separate products in a package, and is a common marketing method for consumer products (Stremersch & Tellis, 2002). Numerous studies have shown that bundling increases consumer acceptance and willingness to pay for the different elements of bundles. Bundling as a business concept has grown rapidly in digital products like music (e.g. Spotify), and entertainment (e.g. Netflix).

Usually the products sold in bundles are complementary. Looking at MaaS, it can be argued that the services to be bundled are not complementary but rather substitutionary. Indeed this is the case for certain origin destination pairings. For example: both public transport and a shared car can bring people from A to B. However, when looking at the added value of MaaS bundles one should look at the entire bundle as a substitute to private vehicles. It is therefore that bundles of transport solutions are seen as complementary.

In literature, three types of bundling are distinguished. Pure bundling, tying, and mixed bundling (Venkatesh & Mahajan, 1993). Pure bundling is when a consumer can only buy two or more products together. Tying is when consumers can buy the products together, but also separately. Mixed bundling is when products can be bought separately, but the price of the bundle is lower than the sum of its elements.

Mixed bundling outperforms pure bundling in terms of welfare effects for both consumers and producers (Dansby & Conrad, 1984). An appropriate strategy for MaaS thus seems to be Mixed bundling. According to a study by Mercer Management Consulting (1997) mixed bundles consist of five elements: (1) the package is worth more to the consumer than the "sum of its parts"; (2) the bundle brings order and simplicity to a set of confusing or tedious choices; (3) the bundle solves a problem for the consumer; (4) the bundle is focused and lean in an effort to avoid carrying or including options, goods or services the consumer has no use for; and (5) the bundle generates interest or even controversy.

2.2.1 Governance of MaaS bundling

In the case of MaaS, bundling entails not the integration of products by one provider, but integrating services offered by multiple mobility providers. This multi-actor nature has consequences for the way it is to be offered. A service delivery model has to be established which brings together a variety of actors of both commercial and non-commercial domain. This is often referred to as a MaaS 'ecosystem', which is displayed in the Figure below (Kamargianni & Matyas, 2017). The most important actors and their (changing) roles as a result of MaaS will be discussed in the following sub-sections.

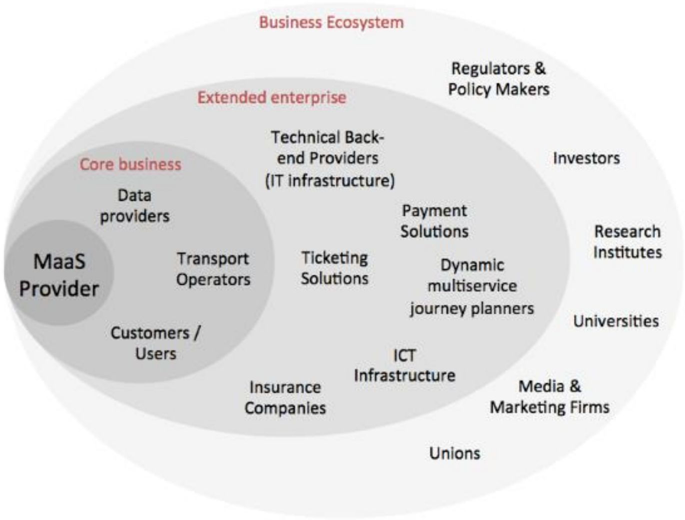

Figure 1 - Business Ecosystem MaaS (Kamargianni & Matyas, 2017).

2.2.1.1 MaaS provider

Different service delivery models have different impacts on the way MaaS is offered, and demand different reactions from other actors in the ecosystem. In the MaaS ecosystem, the first question is therefore who will offer MaaS, and in what way. Three different service delivery models of how MaaS can be operated can be distinguished (Jittrapirom, Marchau, van der Heijden, & Meurs, 2018). These are:

1. The apple model
2. The bol.com model
3. The eBay model

In the apple model, MaaS services are delivered by a transport operator that, besides delivering their own transport services, also integrates the services of other transport providers to end-users in order to create added value to them. Often these companies are public transport companies that have partnered up with other companies in order to provide the end-user with added value. In the Netherlands, this service model is currently being developed by the 4 largest public transport providers.

The bol.com model is a service delivery model for operating MaaS services executed by an independent service company (i.e. having no affiliations with transport operators). This integrator bundles services of other transport operators (such as seats in a bus) and resells them to end-users. Multiple companies are currently developing this type of service models in the Netherlands.

The eBay model is a governance model for operating MaaS in which there is a digital platform that acts as intermediary between end user and transport provider. This platform combines supply with demand by knowing network conditions. The difference between the bol.com model and the eBay model is thus from who the user buys the service.

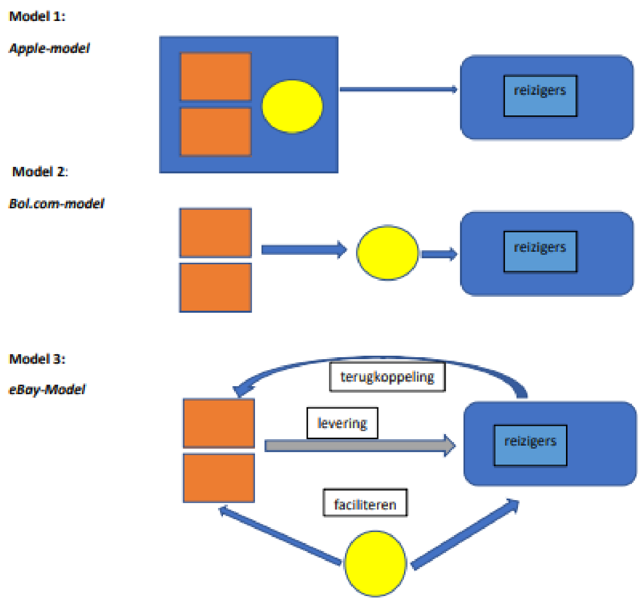

Figure 2 - Schematic overview relationships transport provider, MaaS operator and user (MuConsult, 2017)

2.2.1.2 Transport operators

Depending on the service delivery model, a transport operator is either both a MaaS provider and a transport operator, or just a transport operator. Transport operators can be both public or private operators. A shift in operations of the transport operators might be needed depending on the service delivery model, because some operations (like customer relationships and marketing) might no longer be necessary because the MaaS operator will take care of it. This loss of customer relationship is something public transport companies generally fear, making them act strategically when it comes to cooperating with MaaS providers.

2.2.1.3 Governments

Governments wish to steer the outcome of MaaS in a more sustainable direction. Currently governments set out contracts for transport operators to operate public transport services for end users. They regulate the market by setting performance indicators. In the case of having an intermediary Maas operator, the relationship with transport operators changes. They have no direct influence on the service provision of the MaaS operator. They can choose to take the role of orchestrator, engage in public-private partnerships or can leave the initiative to privately owned organizations.

2.2.2 Examples of MaaS bundles in practice

Two MaaS schemes have so far been implemented that reached level 3 of integration, hence making use of mobility bundles. These are Whim and UbiGo. Whim is currently still operational while UbiGo was a pilot that took place between 2013 and 2014 in Gothenburg, Sweden, during which 195 participants tested the service.

The UbiGo service bundled different transport services to fit individual needs' and requirements. Bundles integrated the modalities: public transport, taxi, car- and bike sharing, as well as rental cars. The amounts of service offerings were specified as follows: for public transport as days in one or more zones, car sharing as hours, car rental as days, bike-sharing as minutes and taxi as distance. The bundles were tailored towards the users, and prepaid. The combination of services was cheaper than the individual elements. Credit could be added, and rolled over to the next month. Users could access their travel services through a mobile application, that allowed them to plan, book, pay and receive support for trips. Additionally, the service included an improved travel guarantee.

Whim is currently operational in Helsinki, Antwerp and the West Midlands. In each region they offer two types a pay-as-you-go option. In Helsinki and Antwerp they also offer bundles. The pay as you go use standard pricing for modes included, and is thus according to the scope of this research not considered as MaaS bundle. The offered bundles in the two cities differ somewhat according to the regional context.

In Helsinki there are three different bundles: Whim Urban, Whim Weekend, and Whim Unlimited. Whim Urban offers unlimited urban public transport pass (which includes buses, metro, ferry and commuter trains inside the HSL area, unlimited shared city bikes, a discount on taxi rides (up to 5km rides) and a discount on car rental. Fees start at 62 euro / 30 days, up to 159 euro / 30 days, depending on the amount of zones that are wished to be covered for the public transport pass.

Whim weekend consists of the same elements but additionally includes the possibility to rent a car on any weekend for free. This car class can be upgraded for an additional fee, Furthermore, the bundle offers a discount on taxi rides no matter the distance. Package prices start at 249 euro / 30 days, up to 346 euro / 30 days depending on the amount of public transport zones.

Whim unlimited offers the prospect of having a car without owning one. Each day, users can choose to either use unlimited taxi rides up to 5km, or rent a car of which the first two hours are free of charge. Next to that, unlimited public transport, and shared city bike usage is included. This bundle starts at €499/month, up to 596 euro / month.

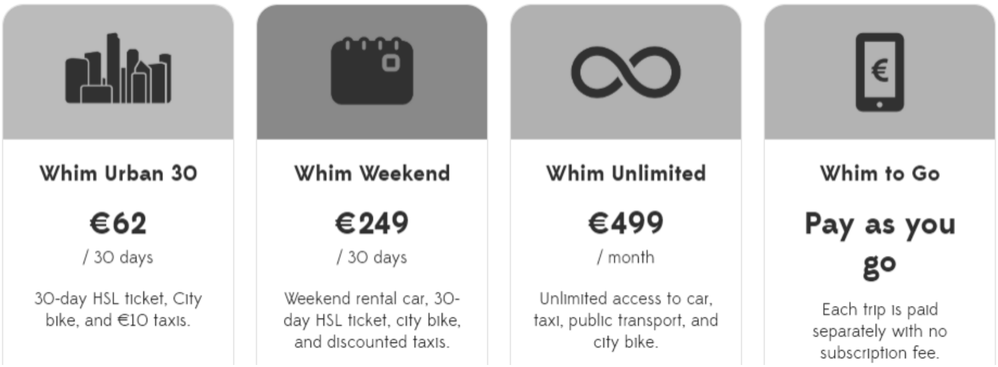

Figure 3 - Whim bundles

In Antwerp, next to the pay-as-you-go option, there is only one bundle which is 'Whim Everyday'. This bundle offers unlimited public transport usage in the city (which consists of bus and tram), unlimited city bikes trips under 30 minutes, a discount on taxi rides up to 5km, and a discount on rental cars. The package costs 55 euro / month.

2.2.3 Examples of MaaS bundles in scientific publications

There are a few examples of stated preference surveys in which MaaS bundles were composed.

(Matyas & Kamargianni, 2017) designed a stated choice survey for the London area. In terms of modalities, the survey included public transport, bike sharing, taxi and car sharing. Public transport consisted of bus, tubes, over ground, docklands light rail, tram, rail and riverboat but were lumped together in order to simplify the choice task. The ranges of this attribute were, "none", "unlimited bus" and "unlimited public transport in your zone". For the bike-sharing component, the researchers included currently available Santander city-bike, with either no bike-sharing included, or unlimited rides up to 30 minutes. Taxi was included by lumping all different taxi companies and ride-hailing services (i.e. Uber) together, and offered to the user pivoted based on their current taxi usage. The attribute levels ranged between (current taxi usage)*0.8/1 /1.1 /1.3/1.5. Car sharing was included as being short term business to consumer car rental services that could be rented by the hour or minute. Similar to taxi, pivoting with the same levels was used to vary the attribute ranges.

Other than the modes included in the bundles, the choice experiment included the price, which was presented as (the sum of base prices)*0.5/0.6/0.65/0.75/0.8/0.9/1/1.1. Also, transferability of the credits to the next month was varied as attribute, between either having no possibility of transferring credits to the next month, or being able to transfer all credits.

(Ho, Hensher, Mulley, & Wong, 2018) designed a stated choice survey for the Sydney Metropolitan area to investigate the potential uptake of MaaS bundles. They pivoted the offer around respondent's current travel behavior. Offers included only the existing transport options: public transport, taxi, UberPOOL and car share. Public transport was included as number of days with unlimited use. Car share as hours. Taxi and UberPOOL as discounts. In terms of car share, two additional mode specific attributes were included. These are: selecting the advance booking time, and the attribute whether car-sharing was on a one-way or return basis. The one-way car-sharing attribute served as a proxy for investigating preferences for autonomous vehicles under a sharing model. Bicycle sharing was not included in the bundle. Because of its limited market share in Sydney.

The costs were based on existing weekly bundles of public transport, current car-share costs with discounts, and discounts on UberPOOL and taxi. Additionally, it was varied whether the credits could be transferred to the next month or not.

Ratilainen (2017) executed a stated preference study towards travelers preferences for MaaS bundles in the Helsinki area. The bundles in the experiment included public transport, car sharing, taxi and bicycle sharing. Public transport was included as number of trips within one zone (varied between 0, 15 and unlimited), car sharing as number of hours (varied between 0, 4 and 8), bike sharing as hours (varied between 0, 4 and 8), taxi as number of trips up to 10km's (varied between 0, 3 and 6). Furthermore, the bundles included the attributes whether credits could be shared with household, and a promise of the pick-up speed (varied between no promise, within 30 minutes, and within 15 minutes). The total costs of the package was varied between 105, 210 and 315 euro.

2.2.4 Overview of bundle attributes

In Table 1, an overview of all MaaS bundles and their attributes is given. As can be seen from the examples, bundles can consist of mode-specific attributes, and non-mode specific attributes. These can be summarized as follows:

- Mode specific attributes
  - Which modes to integrate in the bundle
  - Units of access to services (mins/km's etc.)
  - Upgradability of modes
- Non mode specific attributes
  - Costs
  - Transferability of credits
  - Shareability of credits
  - Pick-up guarantee
  - Pick-up speed

Table 1 - Overview of MaaS bundles and their attributes

	Practice		**Stated preference research**		
	WHIM	**UbiGo**	**Matyas & Kamargianni (2017)**	**Ho et al. (2018)**	**Ratilainen (2017)**
Modes	PT, bike-sharing, car-rental, taxi	PT, bike-sharing, car-sharing, car-rental, taxi	PT, bike sharing, car sharing, taxi,	PT, car-share, taxi, ride-sharing	PT, bike-sharing car-sharing, taxi,
Units	PT: zones Bike-sharing: rides <30 min Car-rental: days Taxi: rides <5km	PT: zones Car-rental: days Car-sharing: hours Bike-sharing: minutes Taxi: distance	PT: zones Bike-sharing: rides <30 min Taxi: miles Car sharing: hours and days	PT: days with unlimited use Car-share: hours Taxi: discount Ride-sharing: discount	PT: zones Car-sharing: hours Bike-sharing: hours Taxi: trips of 10kms
Costs	€49 €499	unknown	(sum of base prices) * 0,5/0,6/ 0,65/0,75/0,8 /0,9/1/1.1	Formulae	€105 €210 €315
Upgradeability	Extra PT zones Larger cars Longer bike rides Longer taxi rides	unknown	Longer bike-share rides Floating car-sharing Larger car-sharing options Luxury cab option Ride-sharing option	One-way car-sharing instead of roundtrip	no
Transferability of credits	No	yes	Yes/no	Yes/no	Yes/No
shareability	No	yes	No	No	Yes/No
Pick-up guarantee	No	Yes	no	No	no
Pick-up speed	Not included	No	Optional	15 min, 30 min, 60 min	No/30 min/15 min

2.3 TRAVEL BEHAVIOR

Travel behavior refers to how people move over space and time. It is the result of an individual decision making process that is derived from the demand for an activity (Mokhtarian & Salomon, 2001). Activity locations are spatially separated, thus necessitate the need to travel. Different travel options exist, that involve 'resistance factors', such as travel time, travel costs but also more intangible resistance factors such as comfort, worries about reliability as so on (Van Wee, Annema, & Banister, 2013). All resistance factors can be summarized into the general costs of travel. Depending on the resources and constraints of individuals, different travel options are available. The next step in the travel behavior decision making process is the evaluation of alternatives. Depending on the 'perception lens' of the individual, general costs of travel are valued differently. This 'perception lens' of individuals is influenced by socio-demographic variables such as age, income etc. When travel options are evaluated, a decision rule explains the choice of people. In travel behavior theory, generally random utility maximization theory is used to explain choices, which states that only when benefits outweigh the costs, trips will be made. This is a reasoned choice process. However, often also unreasoned choice processes play a role in the final decision. Travel behavior is often habitual of nature, which means that travel behavior is often automatic behavior that is acquired by repetition and positive reinforcement (Schwanen et al. 2012). This is thus an unreasoned choice process that influences the decision rule of individuals. Changing behavior and habits also involves a resistance, but can positively influence

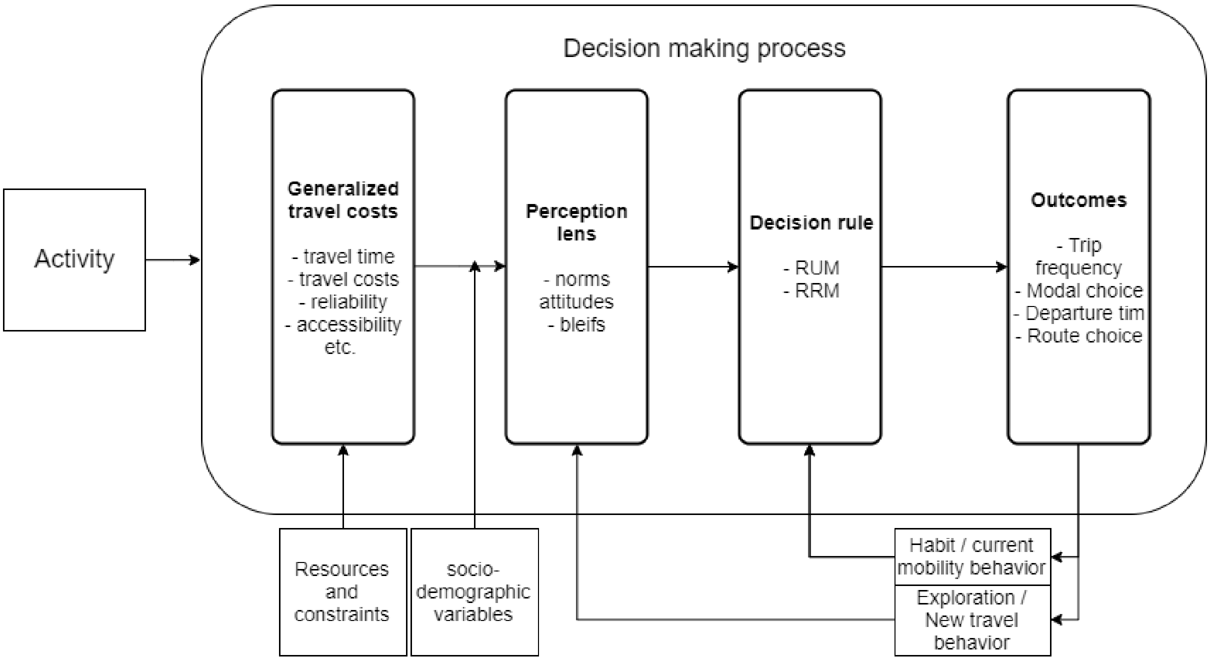

Figure 4 - Decision making process travel behavior (Singleton, 2013)

It is argued, that MaaS lowers the costs of changing behavior, by taking away some of the resistance of multi-modal travelling. Behavioral adjustments can take place in different time horizons i.e. short-, medium- and long-term. Employment and housing location decisions are seen as long-term decisions that determine travel behavior. Medium-term decisions are the decision to own transport modes, or public transport passes. Short term decisions in the context of travel behavior relate to the day to day decisions such as: the number of trips to make, the destination choice, mode choice, time of day choice, and route choice (Ortúzar & Willumsen, 2011).

2.3.1 Analysis: Impacts on travel behavior

There are three types of studies reviewed. Firstly, studies making predictions about the impacts of MaaS based on qualitative research. Secondly, studies reporting empirical data based on trials and pilots. Thirdly, stated preference studies are reviewed.

Each type of study has its limitations and shortcomings. Qualitative research is context dependent, and therefore not generalizable, yet very valuable insights can be gathered. Pilots often have as shortcoming that participants sign up for the trials because they are already interested in the service, and therefore are not representative for an entire population. Benefit of having such a selective group of people however is that they are willing to accept "children's diseases", making it possible to improve the service and show a larger audience that it works. Finally, stated choice experiments face the risk that observed choices in experiments are not necessarily translated into real life choices. Additionally, the risk of hypothetical bias exists, which could be caused by a misunderstanding of the service offered to people in the choice experiment. These shortcomings can be partially tackled with mimicking real world options as closely as possible.

The reviewed literature is retrieved from academic search engines 'Scholar Google' and 'Scopus' with the key-words: "Mobility as a service" AND (impacts OR effects) AND "travel behavior". After reading the abstracts, a total of 12 articles were selected.

2.3.2 Qualitative insights

MaaS' most promising prospect is its effect on private car ownership. It is believed to provide users 'the flexibility of a car, without the need to own one' (Hietanen, 2014). It promises to do so by offering users 'tailor made mobility solutions based on their individual needs' with 'easy access to the most appropriate transport mode or service […] included in a bundle of flexible travel service options' (MaaS Alliance, 2019). Tailoring mobility bundles to the heterogeneous needs of the subscribers (i.e. preferences in mode choice), is beneficial for both he users and transport providers, referred to as collaborative customization (Maria Kamargianni et al., 2016).

(Giesecke et al., 2016) point out that sustainability is a critical aspect of MaaS and therefore MaaS should facilitate the change in users' travel behavior in order to meet their travel needs in a sustainable way. This highlights the importance of users' acceptance and adoption of MaaS. The paper adds that if MaaS is to be interesting for end users, they "need either to be able to save costs while keeping the level of convenience equal (including accessibility, directness, comfort), or increase convenience while keeping the cost level equal".

(König, Eckhardt, Aapaoja, Sochor, & Karlsson, 2016) presents, based on a survey and interviews with experts in the field of MaaS, the stakeholders perspectives and expectations of MaaS in Europe. Most experts believe that MaaS will increase the use of public transport and ride-sharing.

(Ahtela & Viitamo, 2018) used a focus group to investigate the potential of MaaS in commuting in Finland. They found that there is a significant potential for MaaS services. They note however that experience with new mobility services such as ride-sharing makes it easier to adopt and take the full advantage of MaaS.

(Smith, Sochor, & Karlsson, 2018) interviewed 19 MaaS actors active in West-Sweden about their expectations of potential impacts of MaaS. Many of the interviewees pointed out that the diffusion of MaaS would improve the possibilities of using multiple transport services for fulfilling the full range of mobility needs, and therefore impede motivations for car ownership. Initially this is expected to result in abandoning second cars, and eventually also first cars. They note that this will most likely be restricted to first urban and later sub-urban households. Additionally, the interviewees believed that

MaaS would lower entry barriers for included modes, such as car- and bike-sharing, and therefore would increase their usage. They believe that this would come at the expense of private car-use. Furthermore, most interviewees foresaw an increased usage of public transport. Some interviewees noted that however, that the scope of traditional public transport might be reduced, due to the enlarged role of other services.

(Hensher, 2017) also addresses the issue of possible increased car use, as MaaS would allow more users to have access to cars. He adds to that notion that road pricing might be a suitable way of coping with increased attractiveness under MaaS offerings. Pricing measures should also be used in order to shift the distribution of travelers in terms of departure time choice. By having real time information about the network conditions, MaaS makes it possible to steer travel behavior in desired directions.

2.3.3 Insights from practice

Two MaaS schemes have so far been implemented that offered users their services through monthly bundles. These are Whim in Helsinki, and UbiGo in Gothenburg, Sweden. UbiGo took place between 2013 and 2014, during which 195 participants tested the service. Whim is currently operational in Helsinki and Antwerp offering different types of bundles, including public transport, taxi, car-, ride-, and bike-sharing.

The 195 participants of the UbiGo trial were recruited and incentivized with money for not using their car during the trial. This resulted in participants being mostly innovators and/or early adopters. The main motives for adoption were curiosity, convenience and flexibility (Sochor, Karlsson, & Strömberg, 2016). Even though the behavioral results of the trial are very valuable, in terms of adopting no general statements can be made due to this self-selecting process.

In the UbiGo trial, 44% of the participants recorded more decreased private car use (Karlsson, Sochor, & Strömberg, 2016). (Strömberg, Karlsson, & Sochor, 2018) gives insights in the different users, and the extent to which they reduce their car use. The paper divided the participants in four groups: car shedders, car accessors, simplifiers and economizers. Shedders are defined as people who actively wanted to get rid of their cars as they were expensive, inconvenient and bad for the environment. 95% of this group reduced car use. Accessors are people that liked having access to a car, but didn't want to own one. 37% of this group reduced car use. Simplifiers are people that desired a smarter way of handling their multi-modal travelling. 20% of this group decreased their car use. Economizers are people who used UbiGo as a means to save money. 53% of this group reduced car use.

After the UbiGo trial ended, participants were interviewed and surveyed about their perceptions of the service. Participants stated they also felt more negative towards private car and more positive towards public transportation than before. 78.8% of the respondents said they would be interested in becoming a UbiGo customer if it started up again, while 18.1% said yes, under certain conditions, and 3.1% said no. The respondents furthermore responded that they had established new habits during the trial. They noted that choosing for a bundle made them reflect on their current travel behavior and therefore they considered using more alternatives modes (Karlsson et al., 2016). However, it was difficult for them to continue with their newfound travel habits. 51% of those who had changed behavior stated that they would continue with the new behavior. Many of the participants who got their car back after the trial ended reverted to driving again, but not to the same extent as before.

Whim claims to have 60.000 active users per month in Helsinki, with users booking 1.8 million trips as of October 2018 . This means however that the total market share of the app is below 0.5% of the total amount of generated non-vehicular trips (citylab.com). Most users however use the pay-as-you-go version as they are hesitant to opt for the unlimited package straight away. This is also recognized by Strömberg, Rexfelt, Karlsson, & Sochor (2016), which stress the need for trialability as a key element for encouraging adoption.

According to the MaaS global, the company behind Whim, Whim users travel more often with public than their non-Whim counterparts. They also claim that whim users combine taxi 3x more often with public transport than non-Whim users, and therefore identifies their users as more multi-modal. Overall, they claim that their service can replace 38% of daily car trips (MaaS Global, 2019). They note however, that Helsinki has an excellent existing public transport network which is a precondition for its success.

2.3.4 Insights from stated preference research

(Ho et al., 2018) performed a face-to-face stated choice survey of 252 individuals in Sydney, Australia. Almost half of the sampled respondents indicated that they would take MaaS offerings, with infrequent car users being the most likely adopters, and car users the least. The findings however revealed that the willingness to pay for including public transport in MaaS offerings are far lower than the actual tariffs for public transport, which stresses the fact that MaaS plans might not be attractive enough for current public transport users, and that fares might need to be lowered in order to retain current users.

Matyas & Kamargianni (2017) designed a stated preference survey to understand the demand for travel modes in MaaS bundles, and the willingness to pay for them. They found that apart from public transport, respondents generally did not prefer to have other modes (such as car-sharing) in their plans. They think however that this does not necessarily mean that people will not buy or use them, because they can still offer an advantage for users.

In a later study, Matyas & Kamargianni (2018b) explored the potential shaping effects of MaaS bundles with a stated preference experiment. The results show that respondents did not necessarily prefer to have shared modes in their MaaS bundles. However, they were still willing to subscribe to bundles including shared modes. After choosing for a certain bundle including shared modes, over 60% of the respondents indicated that they would be willing to try out these shared modes, even though they had no experience with them before. These initial results support the hypothesis that MaaS bundles may be used as a mobility management tool to introduce more travelers to shared modes.

Kamargianni, Matyas, & Li (2018) performed a survey on attitudes of citizens of London towards MaaS and car ownership. 35% of regular car users reported that they would substitute their car if MaaS was available. Furthermore, 35% of the non-car owners stated they would delay the purchase of a car, and 40% of the respondents said they would not purchase a car at all if MaaS were available. It remains the question however, if they would really do this, and to what extent MaaS must provide added value for them in order for them to do so. On the other hand, 22% of regular public transport users reported that if MaaS with car-sharing and taxi was available, they would substitute part of their trips with car sharing and taxi.

2.3.5 Summarizing

From the literature, different (expected) effects of MaaS bundles on individual travel behavior can be distinguished. These can be summarized to effects on:

- Medium-term travel behavior decisions
  - Decision to delay purchase of a car, or not buy a car at all
  - Decision to get rid of second and/or first car
- Short term travel behavior decisions

- Mode use frequency
- Reduced or induced total number of trips made
- Departure time choice

In order for effects on travel behavior to take place however, adoption is a critical factor. Moreover, the extent of the impacts depend on the current travel behavior of adopters, and the direction of change. While literature generally agrees that the adoption of MaaS bundles results in a changing travel behavior, insights into who these adopters are (i.e. what their current travel behavior is), and to what extent they would change their travel behavior remain largely unknown. Furthermore, the extent to which different bundle configurations influence the extent of behavioral change and adoption is unknown. On top of this identified knowledge gap, no research on the effects of MaaS in the Netherlands exists.

3 METHODOLOGY

As was mentioned in the introduction, research objective is to gain insight into travel behavior adaptations and adoption rates as a result of MaaS bundles in the Netherlands. In order to estimate these effects, different empirical data has to be gathered, and analyzed. In this chapter, the methods used to collect and analyze the data will be elaborated upon.

3.1 DATA COLLECTION

In order to gather the data necessary to answer the previously mentioned sub questions, an online survey will be constructed of which the core consists of a stated-adaptation/stated-choice experiment.

First, as indicator for the different types of travelers based on travel behavior, respondents will be asked to list their currently mobility behavior. This part will consists of frequency of use questions for the most important modalities in the Netherlands, and the ones that will be included in MaaS bundles. These are: car, train, BTM, bike, taxi/uber, shared-car, and shared-bike. BTM and train are measured separately, instead of combining them as a combined public transport indicator, because they are used for different purposes in the Netherlands. Trains are mainly used as intercity connections, hence for longer distances, whereas BTM is mainly used for within-city and neighboring municipalities, hence for shorter distances. Respondents will be asked a 8-point ordinal scale, ranging from (nearly) everyday, to less than once a year how often they use each of the modes. In addition to the mobility behavior in terms of mode use, a range of other mobility indicator such as vehicle possession, public transport subscription packages possession and travel expense compensation will asked to be able to better distinguish the different types of travelers. Furthermore, socio-demographic variables influencing travel behavior are gathered in order to explain the cluster membership of travelers.

Then, the fixed characteristics of the concept of MaaS will be introduced to the respondents by a neutral text, as they are most likely not familiar with the matter. This will limit the assumptions made by the respondent as to what constitutes MaaS. This introduction is based on the nine core concepts of MaaS by (Jittrapirom et al., 2017). Also a video link is provided in case the respondent wants further clarification of the concept. The video can be found here: https://vimeo.com/229846680

The core interest of this research is to examine the impacts of MaaS bundles. Therefore, after the MaaS introduction, the stated adaptation/preference experiment will start. Several bundles, differing on the levels of access to the integrated transport modes (without showing the cost attribute) are presented to the respondents. The attribute levels of each bundle are varied based on an experimental design constructed in Ngene. Respondents are asked to indicate to which degree they would change their travel behavior if they would receive the bundle without having to pay for it (for instance because they receive it from their employer). Travel behavior change is assessed on four different levels, ranging from short-term travel behavior decisions, to more long-term travel behavior decisions. First, they are asked about change mode use, then change in peak-hour avoidance, then change total trip frequency, and finally respondents will receive a car-shedding question.

Change in mode use will be assessed for all modalities as already asked in the first part of the survey, by asking the question: “Would you, and to what extent if so, change you change your mode use of the following modalities if you would receive the above shown bundle?”. It will be measured on a five-point ordinal scale, ranging from ‘a lot less’ to ‘a lot more’, with ‘I would not change anything’ as middle value. If the modality is not currently used, respondents can answer N/A. In order to be able to quantify the qualitative scale, an indication of the percentual increase/decrease of the answer options was provided to the respondents. These factors are: -50% – a lot less, -25% – a little less, 100% – the same; +25% – a little more; to +50% – a lot more.

Change in peak hour avoidance is asked by the question: "Would you travel more often outside of peak-hours if you would receive the above shown bundle?". This is measured on a binary scale, with answer options yes and no. Change in total trip frequency is asked by the question: "Would you, and to what extent, change the total trip frequency if you would receive the above shown bundle?". It is measured on the same five-point ordinal scale as asked for mode change. Car-shedding is measured on a discrete nominal scale, with three answer options. The type of question the respondent receives depends on their current situation (i.e. if he or she currently owns a (lease)-car or not).

After answering questions about behavior change, respondents are shown a price of the bundle, and are asked whether they would be willing to buy the bundle themselves for that price. It is measured on a binary scale with answer options yes and no. Asking this question makes it possible to estimate a discrete choice model as well. Finally, socio-demographic data will be collected about the respondents.

3.1.1 Recruitment of participants

A random sample was sought for this study amongst the inhabitants of the Netherlands between the ages of 15 and 80. This age range was chosen because individuals within this range are considered to be 'independent travelers'. Even though car-sharing requires a driving license, it was chosen not to exclude people younger than 17, or people without licenses from the data, as it is still interesting to record the preferences of potential future car users.

In order to recruit te participants, the authors' personal network was approached, and asked to further spread the survey. Furthermore, the direct colleagues were approached and also asked to share the survey. Furthermore, the link to the online survey was shared on social media platforms, Facebook, Linkedin and Twitter.

3.1.2 Ethical considerations

Since the survey contains human subjects, certain ethical considerations were taken into account. First of all respondents were made clear that they were not obliged to take part in the study, and that they could quit the survey at any time without stating a reason. Secondly, they were provided with the basic details and goals of the study. In the case they had any questions, respondents were provided with the researchers' email address. Additionally, no personal information that could be traced to the individual was asked in order to comply with the GDPR. Before the survey was conducted, permission was requested and granted from the Human Research Ethics Committee of the Delft University of Technology.

3.2 DATA ANALYSIS

With the data gathered through the survey, three different models can be estimated. In figure 4, schematic overview of the relations between variables, and the analysis methods are shown. First of all, based on the current mobility behavior, socio-demographic variables, and an ownership variable, different clusters of respondents can be identified by means of Latent Class cluster Analysis (LCA). Then, the effects of bundle elements on mode change may be estimated by means of regression analysis. Moreover, through the stated preference to adopt a MaaS bundle, a binary discrete choice model can be estimated in order to estimate market shares. Finally, aggregating the results of the discrete choice model, and the regression model, sensitivity analyses of different bundle designs can be performed to predict their impacts. In the sections below, each analysis method will be described in more detail.

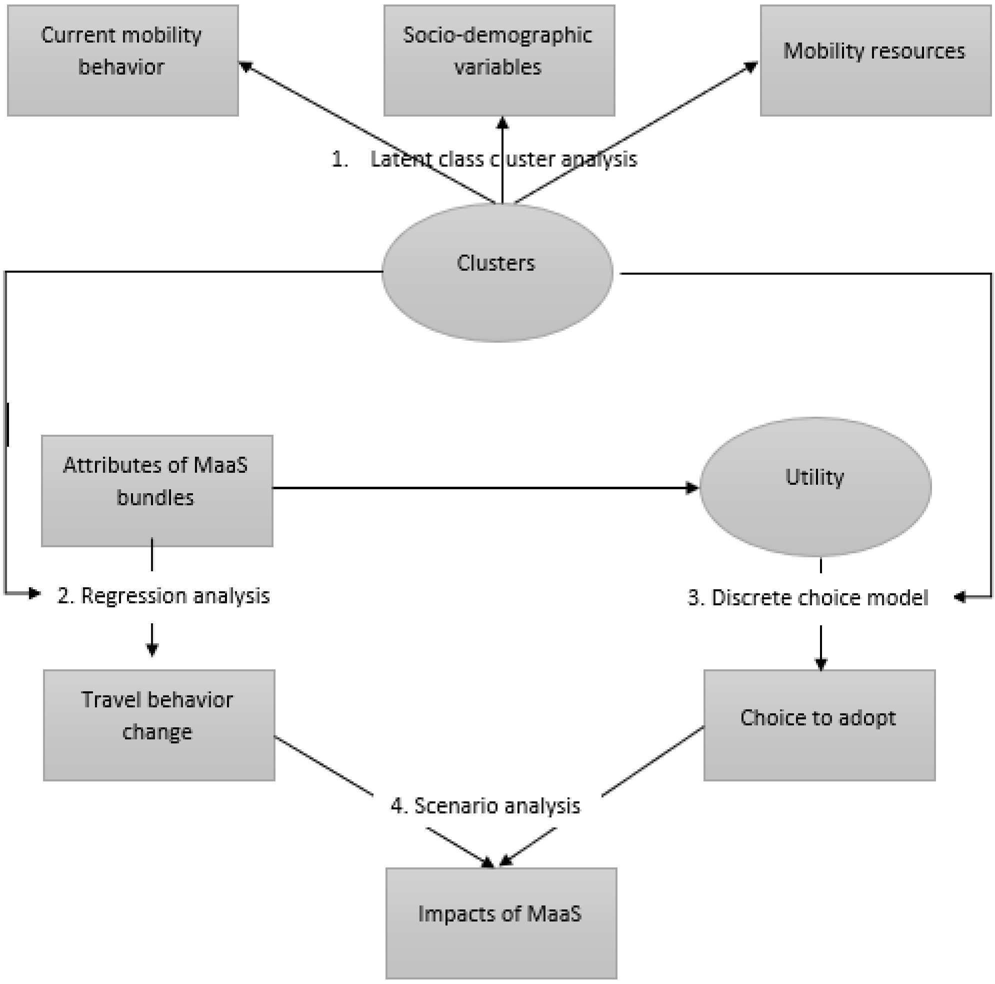

Figure 5 – Variables and analysis methods

3.2.1 Latent class cluster analysis

A LCA is a flexible method to segment respondents into classes that are homogeneous with respect to model indicators that characterize their responses (Nylund, Asparouhov, & Muthén, 2007). The method assumes that each respondent is a member of one, and only one, of K latent clusters. These clusters are latent because they are unobservable directly. One important advantage of LCA is over other clustering algorithms is that with an LCA, a classes can be distinguished regardless whether the indicator variables are continuous, categorical or both. Given the nature of the collected data, this thus is a suitable method to find classes. Furthermore, classes do not have to be decided upon a priori. The classification is probabilistic based on the observed indicators. The software package LatentGold can be used to perform the LCA.

First a measurement model is estimated, which identifies homogeneous latent clusters best on simple indicators. In this research these are the frequency of mode use for a range of different modalities. Then, the number of clusters has to be determined based on the fit of the measurement model. A number of statistical tests are available to determine the number of classes with the highest model fit. They are likelihood ratio chi-squared statistic L^2, information criteria BIC and AIC, or Bivariate

Residuals (BVR). The likelihood ratio statistic represents the amount of association between variables that remains unaccounted for by the model. It is however not a very reliable statistic when data is sparse, or many responses are possible (for instance because many answer options are available for indicators). This is the case in the dataset used in this research because seven indicator variables with eight answer options are assessed. For this reason, information criterions can be used, that take into account the parsimony of the model. Below the formulae for the different criteria are given:

$$AIC = -2\ln(L) + 2 \quad (1)$$

$$BIC = -2\ln(L) + p * \ln(N) \quad (2)$$

In addition to global fit model fit measures, the BVR, which is a local fit measure, can also be used to asses the extent to which the associations between pairs of indicators are explained away by the model. The BVR corresponds to the Pearson Chi-squared divided by the degrees of freedom, hence a value below 3.84 indicates that the association between two indicator variables is adequately accounted for by the model.

Based on the previously mentioned tests, the appropriate number of clusters will be determined. Then both active and inactive covariates will be added to the model. This is called the membership , and by means of backwards elimination insignificant parameters will removed. When the final model remains, the class prediction model outputs will be reported and described in order to interpret the define the different types of travelers. Afterwards, respondents are then assigned to each cluster, to which they have the highest probability of belonging to based on the class prediction model. This will serve as input for the regression analyses.

3.2.2 Regression analyses

For examining the effects of one or more predictor variables on a dependent variable, regression analysis can be used. Most often used, and most easy to interpret is linear regression analysis. An important prerequisite for linear regression is however that the dependent variable has to be on an interval or ratio level. In this research, travel behavior change is measured by different indicators. Mode change and total trip frequency are rated on a five point ordinal scale. Peak hour avoidance on a binary scale, and car-shedding on a categorical scale.

Ordinal regression is type of regression analysis that can handle the ordinal type data. Binary logistic regression is a type of regression analysis that can handle binary type data. Multinomial logistic regression can deal with categorical data. All analyses can be executed in SPSS.

3.2.2.1 Binary logistic regression

As mentioned before, binary logistic regression will be used to analyze the peak hour avoidance element of travel behavior change, since it was measured on a binary scale. The dependent variable in this analysis is thus peak hour avoidance, and the independent variables are the different bundle elements of MaaS. To fit a binary logistic regression model, a set of regression coefficients are estimated that predict the probability of the outcome of interest. This can be written as follows:

$$ln \frac{Prob(event)}{(1-prob(event))} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \beta_k X_k \quad (3)$$

The formula expresses the log of the odds that an event occurs. The coefficients on the right side of the equation explain how much the logit changes based on the values of the predictor variables.

The probability can thus be calculated with the following formula:

$$P = \frac{1}{1+\exp(-(\beta_0 + \beta_k X_k)} \quad (4)$$

3.2.2.2 Ordinal regression analysis

As mentioned before, ordinal regression analysis will be used to assess the impacts on mode use, and total trip frequency as elements of travel behavior change. These elements were measured on ordinal scale, meaning that the outcomes are ordered, but that the actual distance between categories are unknown. The bundle elements will function as independent variables. And change in mode use as dependent variable.

Ordinal builds on binary logistic regression. The event of interest is defined as observing a particular score, or less. The following odds are modelled:

θ_1*= prob(score of 1) / prob(score greater than 1)*

θ_2*= prob(score of 1 or 2) / prob(score greater than 2)*

θ_3*= prob(score of 1, 2, or 3) / prob(score greater than 3)*

θ_4*= prob(score of 1, 2, 3 or 4) / prob(score greater than 4)*

The last category doesn't have odds associated with it since the probability of scoring up to and to 5 is always 1. The formula for an ordinal logistic model for a single independent variable is then:

$$ln\, \theta_j = \alpha - \beta X \quad (5)$$

Where j goes from 1 to the number of categories minus 1.

The β coefficients indicate whether lower or higher scores on the dependent variable are more likely depending on the its direction (positive coefficients for higher scores, and negative coefficients for lower scores). Taking the logarithm of the parameter *-1 gives the ratio of the odds for lower to higher scores. To test whether an effect is statistically significant the Wald statistic can be used. This can be calculated by squaring the ratio of the coefficient to its standard error. Based on a p-value smaller than 0.05, the null-hypothesis that there is no effect can be rejected.

Multiple measures are available to test whether the model fits well. First of all, the model can be compared to the intercept only model. The Chi-square statistic can indicate whether a significant improvement in model fit has occurred. This measure is however not very valuable, since a model provides a significant improvement compared to the null-model rather quickly. Another measure is the goodness-of-fit test. This measure compares observed and expected counts. The model fits well if the observed and expected cell counts are similar. The null-hypothesis that the model fits can be rejected if the goodness-of-fit statistic is small. Finally, the proportional odds assumption has to be tested whether or not the coefficients are equal across all categories on the dependent variable. A large p-value for this tests indicates that the proportional odds assumption holds. If this is not the case, multinomial logistic regression should be considered.

3.2.3 Discrete choice modelling

In order to estimate the willingness to adopt MaaS bundles, the previously explained logistic regression models are extended to account for the decision making process underlying these choices. In order to explain and predict the choices of the respondents, utility is introduced. Utility is a term that refers to total satisfaction received from consuming a good or service. Instead of predicting the loggodds of an alternative, the Utility of an alternative is estimated. By relying on the theory of Randon Utility Maximization, it is assumed that individuals try to maximize their utility when making choices. This is shown in the following formula:

$$U_i > U_j \; \forall \; j \neq i \qquad (6)$$

There are factors that determine the choice of the respondent. Some of these factors are observed, and some are not. The observed factors are labeled x and the unobserved factors are labeled ε. The utility of an alternative i can then be specified as follows:

$$U_i = \sum_m \beta_m * x_m + \varepsilon \qquad (7)$$

In this research, the observed choices will be whether the respondent chooses to buy a bundle or not. Not choosing for a bundle thus represents staying with the status quo. According to Random Utility Maximization theory, choosing to adopt a bundle would only be done if the respondent obtains a net utility from the choice. Hence, the utility of the no-choice alternative can be set to zero, since only the difference in utility matters.

Given the observed choices, a binary discrete choice model can be estimated in which the parameters are estimated that make the data most likely.

$$P_i = \frac{1}{1 + e^{(Vi-0)}} \qquad (8)$$

When parameters have been obtained, the utility of different alternatives can be calculated, and the predicted market shares can be calculated for the different alternatives. This is most easily done with the RUM-MNL model as proposed by McFadden (1974). The formula of choice probabilities is closed form, and is therefore simple to estimate.

$$P_{ni} = \frac{e^{v_{ni}}}{\sum e^{v_{ni}}} \qquad (9)$$

A major shortcoming to this model is however the assumption that the error terms are independently and identically distributed across alternatives and across observations. The MNL model therefore wrongfully assumes that no correlation exists among error distributions of alternatives that are similar. Moreover, the MNL model ignores the possibility that taste heterogeneity across individuals. The mixed logit model can deal with these shortcomings. It was however decided to leave this model outside the scope of this research.

4 MaaS in the Netherlands

In this chapter, the case study area will be introduced, and MaaS will placed in the Dutch context. The Netherlands differs from the previously mentioned cases (Helsinki, London, Gothenburg and Sydney) in several aspects. These other examples are well defined metropolitan areas, where most travel happens inside this metropolis, and public transport is generally organized by one public transport authority. In the Netherlands the population lives more spread throughout the country, with a couple larger cities where much of the travel happens between. Moreover, there are multiple public transport authorities. This makes implementing a MaaS system a national matter.

The scope of this chapter is twofold. First, the demand side; i.e. the travel behavior of the Dutch citizens, is investigated in order to identify the modes that are used and for which purposes. Secondly, the transport supply inside the Netherlands is analyzed. For each type of transport mode, the providers, costs structures, geographical coverage and existing integration initiatives are examined. The analysis leads to a proposition of potential MaaS bundles in the Netherlands. Criteria for the creation of the proposition are: if the mode contributes to daily mobility of Dutch travelers, and if it is realistic to include the service in an upscaled MaaS system that provides nationwide coverage. This proposition will form as input in for chapter 5, in which the survey is designed for the empirical analysis.

4.1 Transport demand

The Netherlands is home to 17,33 million inhabitants (CBS, 2019). On average, inhabitants travel 11.000 kilometers per year (excluding holidays and business trips) (KiM, 2016). On an average day, that is 32km for each traveler. There are regional differences with respect to travelled km’s however. Inhabitants of Flevoland, Groningen and Drenthe travel around 37km a day on average, whereas inhabitants of North- and South-Holland travel only 27km’s a day. These regional differences are explained by the accessibility of activity locations, which are located further away in the less dense provinces.

On average, 30% of the travelled kilometers are made for the purpose of going to and from work. Next to that, 23% and 20% of the travelled kilometers are respectively made for recreative and social purposes. Together these purposes thus make up for most travelled km’s and thus the largest impact can be made when travel behavior is changed for these purposes.

Of the commuting km’s, 77% are executed by private car (most of them occupied by one person), 12% by train and 7% by bicycle. Bus, tram and metro have a relatively low share, with 3% of the travelled km’s.

Interesting to note is the train-bicycle combination. For 44,4% of the trips where train is the main mode, bicycle is used as access or egress mode at the home side (Waard & Visser, 2018). At the activity side, the shared bicycle (OV fiets) is used for 15% of the cases (NS, 2019b). Additionally, BTM is used for respectively 20% and 25% of the access and egress trips at the home-end and the activity-end. Access and egress of BTM at the home-end is mostly walking (around 80%), and to a lesser degree by bike (7%). At the activity-end, walking is the dominant form of access and egress (92%).

Trips made for recreative and social purposes are also mostly traversed by car. Contrary to commuting, leisure trips are often shared. The other percentage of km’s are traversed by other modes. In 2017, 1% of the population owning a driving license used car-sharing (Nijland & van Meerkerk, 2017). Even though this is a rather low share, 20% of the population contemplates becoming a car share user (Harms & Jorritsma, 2016). Car-sharing have high potential to reduce private vehicles. Taxi is used very infrequently in the Netherlands. No data is available about its use.

4.2 TRANSPORT SUPPLY

In the following section, the transport supply in the Netherlands will be analyzed. However, before the transport supply is analyzed, first it is decided which modes would be included in a MaaS proposition

Which modes to integrate in a Dutch MaaS proposition?

Before each mode will be discussed in detail, it has to be determined which modes to integrate in the MaaS bundles in the Netherlands. From the literature study towards MaaS bundles in practice, and other scientific research it became clear that all bundles include at least: public transport and taxi. Next to that, all examples of bundles comprise car-based modalities. The examples differ in the form of offering however; either car-sharing, more traditional car-rental, or both are included. Car-sharing is more relevant for short-term trips, whereas car-rental is more suitable for longer trips such as a complete day, weekend or week. Additionally, bike-sharing was included in all cases except in Sydney, due te the low modal share and poor cycling infrastructure in the city. Instead, ride-sharing was included in the (proposed) bundle combination in Sydney.

Taken these examples into account, and the transport demand in the Netherlands, it can be assumed that public transport will certainly be integrated into any MaaS solution. Next to that, the integration of car-based modalities is imperative. There are simply some trip purposes, and origin-destination pairs that are best traversed by car. Due to the increasing popularity of car sharing, and the fact that it offers an attractive alternative for private car ownership and has, it is more likely that this will be included in MaaS bundles rather than car-rental. Furthermore, given the large- and increasing popularity of the shared bike in the Netherlands, they are expected to be integrated as well. Moreover, even though taxi and ride-hailing have a low market share in the Netherlands, they are likely to be integrated in the bundles, because of their potential to complement public transport, and therefore provide an alternative for door-to-door mobility rather than the private vehicle.

Other (emerging) modes such as shared-scooters, are due to their limited local availability not likely to be included in a scaled up MaaS system as bundle elements (with prepaid access) in the short term

4.2.1 Public transport

Public transport is the transport of passengers by a system available for the general public, typically managed on a schedule, and operated based on established routes, that charges for each trip (Chowdhury & Ceder, 2013). In the Netherlands, the public transport network consists of rail, metro, tram, bus and ferry services. Typically, the distinction of public transport is made between rail and bus, tram, metro & ferry (BTMF).

The rail network in the Netherlands is managed by ProRail. They are responsible for construction, maintenance, the allocation of its capacity, and traffic control. There are different operators offering services on these tracks. The Dutch Railways (NS) is the largest operator, which operates the main rail net. Besides the NS, there are currently 7 regional operators. The ticket prices are based on 'tariff units', which are based on distance, but decrease in additional costs with increasing distance travelled.

BTMF services are publicly tendered per region. There are 12 transport regions in the Netherlands which are served by different operators. The infrastructure for buses is nearly always owned by the road maintenance authority, while the infrastructure for metro and tram are usually owned by the transport companies. Prices are built up based on distance, but differ per region.

Since 2012, travelers can travel with all operators using a smart-card. There are two options for payment, either with a balance, that can be recharged, or with bundles. At the moment, there are 91 different bundles for public transport, offered by different providers (ovchipkaartabonnement.nl, 2019). 16 of these bundles provide nationwide coverage. The focus is on these, given the research scope.

A distinction can be made between bundles that only include rail, or BTMF, or both. Furthermore, a further distinction can be made between bundles that give unlimited access, or give discounts. Discounts can either be restrictive, or non-restrictive bundles. An overview of the types of PT bundles, and their costs are given below.

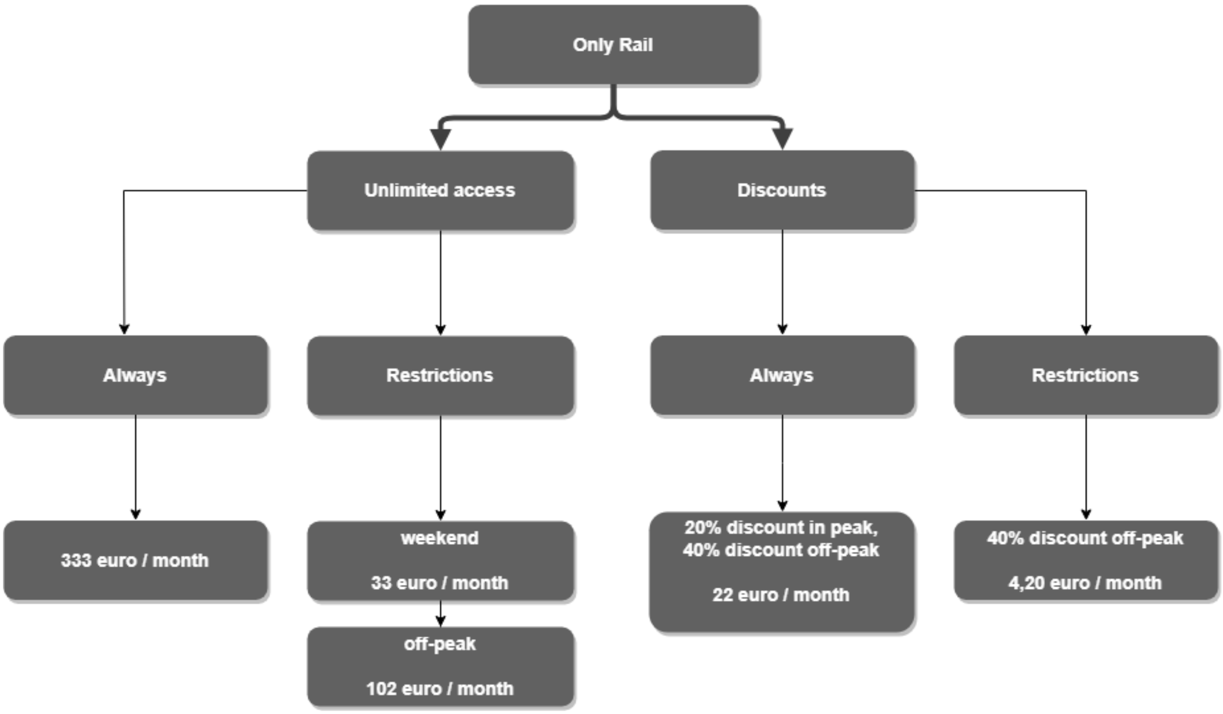

Figure 6 - Rail bundles

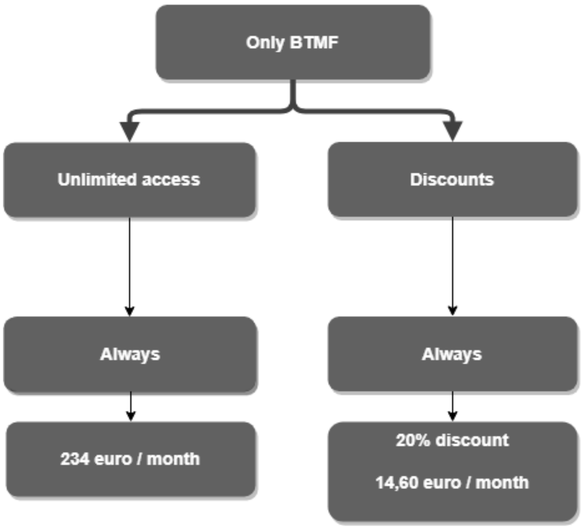

Figure 7 - BTM(F) bundles

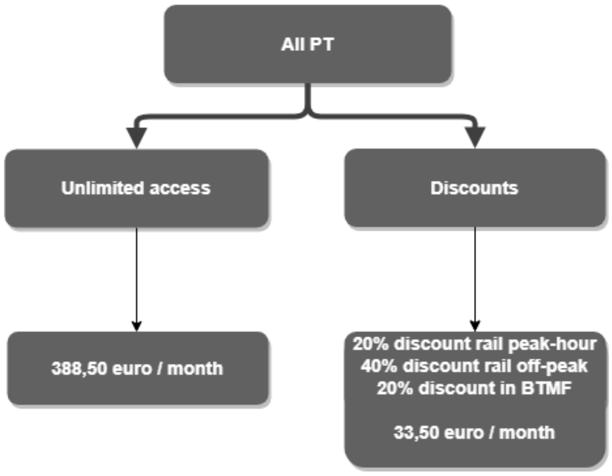

Figure 8 - Integrated PT bundles

How to integrate Public transport in a Dutch MaaS proposition?

Since these services are already offered in bundles, and therefore adequately represent the costs/benefit ratio for the service providers, these bundled offerings will be taken as a reference point for the MaaS proposition. This thus means rail will entail five categories, and BTM two. Since public transport is regarded as the backbone of MaaS, having no rail or BTM included in the proposition does not belong to the options. The minimum service level for both rail and BTM is thus 'always discount', for which the combined base price is €33,50 per month.

4.2.2 Car sharing

Carsharing is a service that allows users to have access to a car, without having to own one. There are different types of car sharing. A division can be made between business-to-consumer (B2C), and peer-to-peer (P2P) car-sharing.

With P2P, vehicles are owned by consumers, which they offer for rent, usually through a platform. The platform takes care of matching the supply to the demand, payment, insurance and road-side assistance. Currently there are two organizations offering these services in the Netherlands: MyWheels and Snappcar. Costs of these services depend on the type of vehicle and availability, but are constructed based on a fixed daily rental fee and additionally fuel cost and an (extra) km fee.

With B2C, vehicles are owned by companies that commercially exploit them. A further division can be made between different types of services: round trip and one-way B2C car-sharing. In the latter, cars can be parked anywhere, and can thus be used for one-way trips. While in the former, cars are positioned on fixed locations, and can thus be used for round-trips,

Currently there is only one provider in the Netherlands offering one-way car-sharing. This is Car2Go which is only active in Amsterdam. According to the company, the service is also only viable in larger cities. A one-time registration fee of 9 euro is required, after which cars can be rented starting from 0,26 euro per minute (but this price is dependent on location, time and type of vehicle).

On the contrary, many B2C are offering round-trip car sharing in the Netherlands. These are: Greenwheels, MyWheels, ConnectCar, Flexcar and Stapp.in. Greenwheels has the largest geographical coverage area and is most well-known, while the other providers are only locally available. Greenwheels already offers bundles to their users, depending on usage. Three different bundles are sold. When only travelling incidentally, there is a bundle that is free of charge. Hourly tariff is then 6 euro, and additionally 0,34 euro / km. For making use of Greenwheels at least once a month, there is a bundle for 10 euro per month. Hourly rates go down to 4 euro, and additional km fee is 0,29 euro. When using Greenwheels at least 3 times a month, there is a bundle for 25 euro / month, which reduce the hourly tariff to 3 euro, and additional fee to 0,24 cent. For all bundles, there are options to rent cars for longer trips as well.

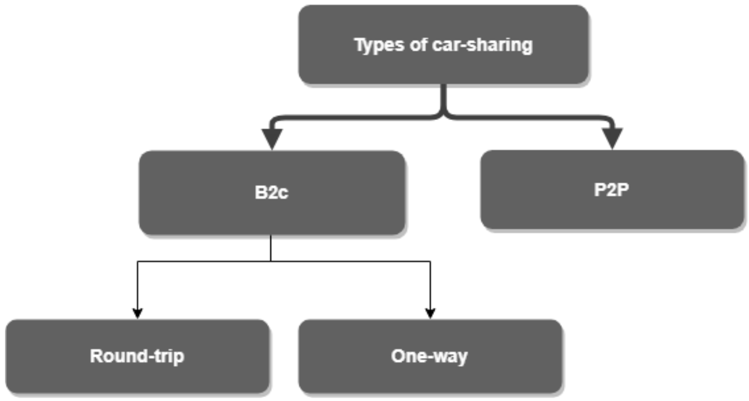

Figure 9 - Types of car-sharing

> ***How to integrate car-sharing in a Dutch MaaS proposition?***
>
> B2C car-sharing is most well known in the Netherlands, however P2P car-sharing has larger geographical coverage. Given the context of the trip, it depends which type of car-sharing service is most suitable. A further distinction can be made between one-way and round-trip car-sharing, which depends on the regional context. The promise of MaaS; unburdening and solving these complexity decision issues make it likely to assume that, for matters of simplicity, there will be no direct difference for users. It is more relevant that a car is available, for whatever purpose, at whatever location for each user. Since GreenWheels is the largest provider in the Netherlands, and additionally they already offer their services in bundled offerings, this business model will be taken as a reference for the MaaS proposition. In the MaaS proposition for this research, the three different bundles that Greenwheels offers will be included with example situations to make the costs more tangible (e.g. a day trip of 100km using the car for 6 hours).

4.2.3 Taxi / ride hailing

Taxis are demand responsive transport services that transport people to a destination that they decide, from a location that they request, or from a taxi standing place. Traditionally, these could be hailed from the streets, or reserved by means of a call. The tariffs in the Netherlands are built up based on a starting fee, a kilometer fee and a time fee. For a normal 4-person cab, prices are €2,67 starting fee, €1,95 / kilometer and €0,32 / minute. For a taxi trip of 5 km in a city, where average speed of 32 km/h this comes down to €15,42. Many taxi companies use a maximum city fee however. For instance, UTC, a taxi company in Utrecht uses a maximum fee of €14,50 for trips within the city.

More recently, ride-hailing providers came into existence, which offer similar services, but allow users to book a 'taxi' with a mobile application. The app shows the flat fare in advance, and allows users to pay directly through the app. This gives users more convenience and transparency. Another difference in comparison to traditional taxi's lies in the business models. Taxis are regulated by cities, which usually involves a difficult process of obtaining a license, and minimum fares that they had to charge. Ride-hailing services have worked their way around these regulations, and could therefore charge lower prices, making ride-hailing often more cost friendly.

Uber, the largest ride-hailing provider, is active in Amsterdam, Rotterdam, the Hague, Utrecht and Eindhoven. They use a starting fee of €1,40, a kilometer charge of €1,20 and a time fee of €0,26/minute. As can be seen, this comes down to a much lower price. For a 5km trip at an average of 32km/h this would yield to €9,84. Prices can vary however according to demand. If there is more demand than supply, they go up.

How to integrate taxi/ride-hailing in a Dutch MaaS proposition?

In a scaled up MaaS system, collaborating taxi/ride-hailing companies would be integrated on platform, which would match passengers to rides with a smart algorithm based on origin, destination and location of the driver. Again, for sake of simplicity there would be no difference noticeable for users. Given the relatively small cities in the Netherlands, it is unlikely that this mode would be used to traverse long distances. For the MaaS proposition of this research a number of trips up to 5km for the price of what is currently offered by Uber (roughly 10 euro) will be taken as a reference point

4.2.4 Bike sharing

Bike-sharing systems allow users to access bicycles on as as-needed basis. There are two types of bike-sharing systems in the Netherlands: free-floating bike sharing, and station based bike-sharing. In the latter, bikes have to be returned at the same place where it was rented. In various cities worldwide (e.g. in Paris, Antwerp and Barcelona), systems exist with multiple docking stations located around the city where bikes can be rented and returned, but in the Netherlands these don't exist. Instead, station based bike-sharing systems are available at train stations. Free floating bike-sharing systems can be opened with the use of a smart-lock, connected to an application, and left anywhere after a ride is finished.

The most well-known station based bike-sharing system in the Netherlands is the OV-fiets, which is exploited by the NS, and is mainly available at train stations. Bikes can be rented for €3,85 / 24 hours, and have to be returned at the same location. Payment is done through the OV chipcard, for which no registration is required.

Free floating bike-sharing operators are plentiful. Each operator usually has its own application that can be used to locate and open the bikes, however, recently, 10 different operators have started working together on an application that shows the availability of all bicycles. With this cooperation, 90% of all free floating shared bikes in the Netherlands are covered. Different operators still maintain their own costs structure, but it is to be expected that these will converge. Mobike, the largest company, currently offers access to their bikes in two ways: €1,- / 40 minutes, or unlimited trips up to 40 minutes for €7,50 per month.

How to include Bike-sharing in a Dutch MaaS proposition

Free-floating bike-sharing providers already work with a smart-lock system that makes this service possible. The NS is also working on implementing a smart-lock to introduce this same kind of service for their OV fiets (NS, 2019a). They expect to launch this service at the end of this year. For the MaaS proposition of this research it was therefore chosen to include bike sharing as free-floating bike sharing because it provides the users with more flexibility. For the proposition, the business model of MoBike will be taken as a reference since they already provide a monthly bundle. The attributes will thus be, not including shared-bikes, pay-per use or the unlimited bundle for which the base prices are taken.

4.2.5 Non mode-specific attributes

One of the most important determinants of choice for MaaS is its price. It was chosen to only list the total costs of the bundle, rather than showing the individual price of each element. To determine the total costs of the bundle, the base prices of the elements included in the bundle are multiplied by a cost attribute.

The next non mode-specific attribute is transferability. This attribute refers to whether left over credits can be taken to the next month. This is an important design attribute, since it can have an influence on inducing taxi trips.

5 SURVEY DESIGN

As mentioned in the introduction, the aim of this research is to gain insight both into potential changing behavior as a result of MaaS, as well as the willingness to adopt MaaS, by travelers in the Netherlands. Since there are no existing MaaS alternatives to date, a digital survey was distributed to gather data. A stated adaptation/choice experiment was part of this survey. This chapter will discuss and present the construction of the survey. In section 5.1 the structure of the combined stated choice/adaptation experiment is elaborated upon. In section 5.2 the relevant attributes and attribute levels are presented. These are selected based on the previous chapter. In section 5.3 the construction of the experimental design is substantiated, which consists of three steps; the model specification, generation of the experimental design, and finally the construction of the survey.

5.1 COMBINED STATED CHOICE/ADAPTATION

Two experiments will be integrated into one survey. A stated adaptation experiment and a stated choice experiment. Both experiments require a particular configuration. In stated choice experiments, generally the respondent is faced with two or three hypothetical choice alternatives for which he or she is supposed choose the most preferred option. In a stated adaptation experiment, respondents are confronted with a change in their environment, for instance a changing policy or the introduction of a technological innovation, and are then asked to envisage their behavioral responses. In this experiment, the MaaS bundle will be introduced as the change in the respondents environment. The same MaaS bundle is used in the stated choice experiment so that the results can be combined. This means that for every bundle shown to the respondent in the choice experiment, there also needs to be a stated adaptation part. This would lead to a very lengthy survey if in each choice task two or three bundles are shown. The decision was therefore made to limit the bundle shown in the stated choice part to the respondent to one per time. A binary choice to adopt or not to adopt was thus only possible. This provides less information about trade-offs people make, but it weighs up against the lengthiness the survey would otherwise have.

Then, the order of the two parts of the experiment has to be decided. When first asking respondents to choose between a number of bundles, and then asking them if and how they would change their behavior, the risk exists that respondents will try to explain their choice made before, with choosing for certain behavioral response. However, vice versa the same possibility exists. In literature this problem is referred to as cognitive dissonance. In order to resolve this issue, the decision was made to decouple the two mechanisms. Firstly the respondent is asked how he or she would change their behavior, in the case that a certain bundle is given to them, for instance by their employee or the government. Therefore, the cost element is not yet included in this part. Then, the price is shown and respondents after which they are asked if they would adopt or not adopt the bundle themselves for that given price.

5.2 ATTRIBUTES AND ATTRIBUTE LEVELS

As discussed in the previous chapter, the included modes in the MaaS bundles are rail, BTM, car-sharing, bike-sharing, taxi trips, transferability of taxi trips to the next month and price of the bundle. These are shown in Table 3. Important considerations in the creation of the experiment are (1) that the most important attributes, both for respondents as well as for policy or design, have to be included; (2) sufficient variation is created in choice situations, such that parameters can be estimated reliably, (3) that the choice task does not exhaust the respondent, and (4) that choice situations resemble real world choices as much as possible, so that results are valid. In order to limit response burden, the decision was made to only base MaaS bundles on current nation-wide existing modes, and basing their inclusion in MaaS bundles on current propositions as offered by the providers.

5.2.1 Rail

The rail attribute levels are based on the current bundles offered by the Dutch Railways (NS). Five available attribute levels were specified. However, the choice was made to limit the number of attribute levels to four, since otherwise a much larger experimental design would have to be made, since it Is generally more sensible to either have all even, or all odd numbers of attribute levels (ChoiceMetrics, 2018). It was chosen to excluded the lowest level attribute:; off-peak discount, because it offers the least attractive proposition. The remaining attribute levels are: (1) always discount, (2) weekend-free, and off-peak discount, (3) free-off peak and weekend-free, (4) and always free.

5.2.2 BTM

The BTM attribute levels are based on the bundles offered with nationwide coverage. Two bundles were specified. Both identified attribute levels are included. These are (1) always discount, and (2) unlimited travelling. The first gives a 20% discount on all rides, and the second provides unlimited access to BTM in the Netherlands.

5.2.3 Car-sharing

For car-sharing, there are three attribute levels. For the same reasons as for rail, it was decided however to limit the attribute levels to two. It was chosen to remove the least attractive car-sharing attribute, which would costs 6 euro per hour + 34 cents per km. No monthly costs are associated with this bundle, and therefore no extra value is added with including this attribute in the MaaS bundle.

5.2.4 Bike-sharing

The bike sharing attribute will be based on the current proposition by the largest bike-sharing provider in the Netherlands. Two types of offerings are currently available. These are either a pay-per-use fee of 1 euro for rides up to 40 minutes, or unlimited access. Both are included in the experimental design.

5.2.5 Taxi/Ride-hailing

For the inclusion of taxi/ride-hailing it was decided to keep the number of trips low, because it does not add much to daily mobility. However, also a wide range is preferred compared to a low range since extrapolation is less reliable than interpolation. Therefore a maximum of 6 taxi trips was chosen, and a minimum of 0. This leads to a range of [0,2,4,6] taxi trips.

5.2.6 Costs

Costs will be included as a continuous variable. Again, a wide range is desirable. The costs are varied between the sum of the attribute levels, ranging between the minimum package, and the maximum package.

The minimum MaaS bundle, consisting of 'always discount' for both rail and BTM, car-sharing for 4 euro per hour + 0,29 cent per km, bike sharing for 1 euro per 40 minutes and no taxi trips costs €48,50. This was rounded off to €50. The highest bundle consisting of unlimited access for both rail and BTM, car-sharing for 3 euro per hour + 0,24 cent per km, unlimited rides up to 40 min and 6 included taxi-trips adds up to a total of €481,- . Nonetheless, the assumption was made that a 'max' bundle could be offered for a discount, since this is one of the identified characteristics of bundles. This discount was set to be 90% of the total cost price. The cost was therefore varied on 4 levels, with steps of 125 euro. All in all, this leads to the attributes and levels as specified in Table 2.

Table 2 - Attributes and attribute levels

	0	1	2	3
Rail (a)	Always discount	Weekend free, and off-peak discount	Free off-peak and weekend	Unlimited travelling
Taxi/ride-hailing (b)	0 trips up to 5km	2 trips up to 5km	4 trips up to 5km	6 trips up to 5km
Costs (c)	50	175	300	425
Car-sharing (d)	€4 / hour + €0,29 / km	€3 / hour + €0,24 / km		
BTM (e)	Always discount	Unlimited travelling		
Bike (f)	€1,00 per trip up to 40 minutes	Unlimited trips up to 40 min		
Transferability of credits (g)	No	Yes		

5.3 EXPERIMENTAL DESIGN

In creating the experimental design of the survey, three main steps have to be undertaken. First of all, a complete model specification with all parameters to be estimated has to be determined. Based on this model specification, an experimental design type has to be selected and then the design can be generated (ChoiceMetrics, 2018). The experimental design can then be incorporated in a questionnaire.

5.3.1 Step 1 – Model specification

The first step is the model specification. There will be two alternatives. One MaaS bundle, and a no-choice option. The utilities are specified as follows (note that this model specification will also be used as input for the regression models, but then utility is replaced by the logodds):

U_{bundle} = *βRail ∗ Rail [0,1,2,3] + βBTM ∗ BTM [0,1] + βCar ∗ Car [0,1] + βtaxi ∗ taxi [0,2,4,6] + βBike ∗ Bike [0,1] + βCost ∗ Cost [50,175,300,425] + βCtransferability ∗ Transferability [0,1] +* ε_{bundle}

$U_{opt-out} = 0$

Where:
U_{bundle} *= utility of MaaS bundle*
$U_{opt-out}$ *= utility of no-choice*
βRail = parameter for Rail attribute
βBTM = parameter for BTM attribute
βCar = parameter for Car-sharing attribute
βtaxi = parameter for taxi attribute
βBike = parameter for bike-sharing attribute
βCost = parameter for cost attribute
βCtransfer = parameter for transferability attribute
$ASC_{opt-out}$ *= alternative specific constant for opt-out alternative*

5.3.2 Step 2 – Generation of experimental design

The next step is generating an experimental design for the construction of hypothetical choice tasks for the respondents. One can choose between a full factorial design, meaning that all possible combinations of all attribute levels are constructed, or a fractional factorial design. The former would result in a too large number of choice sets. The fractional factorial design allows to reduce the number of choice sets. Three different types fractional factorial designs exists: random designs, orthogonal designs and efficient designs. Random designs are randomly selected choice sets from a full factorial experimental design. A disadvantage of this design is the high probability of correlated attributes. Orthogonal designs are constructed by a mathematical plan to minimize the correlation between the attributes, while efficient designs are constructed to result in data with as small as possible standard errors. When some prior information about the parameters is available, efficient designs are preferred, as they outperform orthogonal designs by maximizing the trade-offs obtained from each choice task. In the case of this research it was chosen not to perform an efficient design as there is no prior information about parameters available, and executing a pilot survey would result extra work, where time for data collection was limited.

The experimental design was created in software package Ngene. A pilot survey was first created based on an experimental design 2 blocks and 8 choice tasks per respondent. This resulted however in a survey that took over 15 minutes to finish. It was therefore chosen to reduce the number of choice sets to 4 per respondent by dividing the rows over 4 blocks. Attribute level balance was satisfied for the entire experimental design, however in each block individually this was not the case. The syntaxes used to generate the pilot survey and the final survey can be found in .

5.3.3 Step 3 – Constructing the survey

After the experimental design was created, it was translated into a survey. The survey was constructed in SurveyGizmo. A full copy of the final survey can be found in Appendix E. It consists of the following parts:

1. Welcome text
2. Questions: Current mobility behavior
3. MaaS introduction
4. Questions: Stated choice/adaptation experiment – MaaS bundles
    a. Choice experiment introduction
    b. Travel behavior change
        i. Mode use
        ii. Total trip frequency
        iii. Peak-hour avoidance
        iv. Car-shedding
    c. Stated choice
5. Questions: Socio-demographics
6. End text

The bundles are shown to the respondents by means of a picture. An example is shown below:

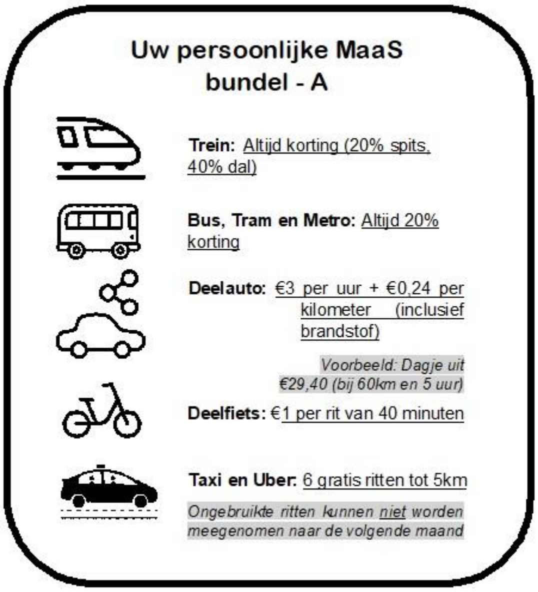

Figure 10 - Example bundle choice experiment

5.4 SURVEY TESTING

The survey was tested with a handful of people, who provided feedback in order to improve the final version. Several comments were made about the length of the survey. At first it consisted of 2 blocks of 8 bundles. This however on average took people over 15 minutes to finish completely. It was therefore decided to construct 4 blocks, of 4 choice sets each, and thereby almost halving the completion time. Other comments were made about the introduction text. It was not neutral, and gave a too pretty picture of MaaS. The text was therefore edited to become neutral. Furthermore in terms of lay-out also several modifications have been made to make it function better on both smart-phone and desktop. Finally other textual errors were removed.

6 RESULTS

This chapter presents the results of the survey. In Section 6.1 the descriptive results of the collected data are provided. In Section 6.2 the steps taken to prepare the data for the analyses are explained. In section 6.2 the results of the latent class cluster analysis are provided, aimed to answer sub question 1*: "Which types of travelers can be identified based on their current travel pattern, and what are their characteristics?".* In Section 6.4 and 6.5 the results of the regression analysis are provided aimed to answer sub question 2: "*What are the effects of bundle elements on travel behavior change of the different identified travelers in the Netherlands?".* In section 6.6 the results of the discrete model are provided aimed to answer sub question 3*: "What are the effects of bundle elements on the willingness to adopt MaaS for the different identified travelers in the Netherlands?".* These results together are combined into a model, which will be applied in chapter 7.

6.1 DESCRIPTIVE RESULTS

Data was gathered by means of online snowballing. A link to the survey was posted on Facebook, LinkedIn and Twitter. This link was shared by two people with a large network in transport and MaaS related fields. Furthermore a direct email to 149 colleagues was sent with the invitation to complete the survey. Additionally, 50 direct emails were sent to people working in transport related industries, with the invitation to complete and share the survey. Entry to the survey was kept open between the 2nd and 12th of September. In this time, 330 people opened the survey, and 203 people finished it. This means the dropout rate is 40%, which is quite high. Section 8.4 discusses possible reasons for this high drop-out rate. Since there are four choice/adaptation tasks per respondent, there are a total of 812 observations. Blocking was used to divide the 16 constructed choice sets from the experimental design over the respondents. 23,7% completed the choice sets of block 1, 24,7% block 2, 25,3% block 3, and 26,2% block 4. This distribution is adequate enough to prevent the data from being multicollinear.

The sample characteristics are given in Table 3. Whenever population data is available, it is also displayed. These data were retrieved from CBS Statline.

Table 3 - Descriptive statistics results

			Percentage Sample	**Percentage Population (CBS)**
Gender	Male		63,5	49,4
	Female		36,5	50,6
Age	15-25		14,3	13,7
	25-45		51,7	45,2
	45-65		31	29,3
	65-80		2,5	11,6
	80+		0,5	3,3
Educational level	Low	Lower school	0,5	16,2
		VMBO/MAVO	1,5	
	Medium	HAVO	0,5	27,1
		VWO	3,9	
		MBO	3,9	
	High	HBO	24,1	56,6
		WO Bachelor	7,4	
		WO Master	51,2	

		PhD	6,9	
Income	Less than 10.000 euro		7,4	-
	10.000-20.000		4,4	-
	20.000-30.000		4,9	-
	30.000-40.000		13,3	-
	40.000-50.000		10,8	-
	50.000-60.000		4,4	-
	60.000-70.000		4,4	-
	70.000-80.000		7,9	-
	80.000-90.000		5,4	-
	90.000-100.000		3	-
	More than 100.000		16,7	-
	Secret		17,2	-
# of people in household	1		31,5	38,33
	2		33	32,64
	3		13,3	11,77
	4		17,2	12,13
	More than 4		4,9	5,13
Living environment	Rural (21,8%)	Rural periphery	5,4	30
		Rural accessible	2	
		Small town outskirt	10,3	
		Small town central	3,9	
	Sub-urban (15,7%)	Suburban small city	10,8	39
		Center small city	4,9	
	Urban (62,5%)	Suburban large city	25,6	51
		Centre large city	36,9	
Working situation	Student		9,4	11,1
	Part-time working		17,7	-
	Full-time working		48,3	-
	Self-employed		14,8	-
	Unemployed		4,4	-
	Retired		4,9	13,4
Driving license	Yes		91,1	
	No		8,9	
Car possession	Zero		36	49,6
	1		40,9	50,4
	2		21,2	
	More than 2		2	

In appendix B the representativeness of the sample was tested by means of chi-square tests. It was found that the sample is overall not entirely representative of the population, but that for the aims of this research this is not found to be too much of a problem. As can be seen in Table 3, men are overrepresented in the sample. Men are more often found to be car owners. This could be the reason why also car possession is higher in the sample compared to the population. As MaaS, and this survey are specifically aimed at understanding the tendency to reduce vehicle use as a result of MaaS, this is not expected to influence the representativity of the sample too much.

In terms of age groups, the distribution is rather representative. The oldest age groups are slightly underrepresented, and the younger groups slightly overrepresented. This is however not expected to influence the results too much.

Highly educated people are overrepresented in the sample. Almost the entire sample is categorized as highly educated. This means the influence of education level can only be tested to a limited extent Furthermore, a large share of people indicated that they did not want to enclose information about their income. Since no information is available about the income of people that indicated not to enclose information about their income, no effects of income can be tested.

A large share of the sample lives in urban environments. Since MaaS will most likely first be aimed towards urban users, this overrepresentation can still be considered as representative for the target group.

6.2 DATA PREPARATION

Before the analyses could start, the datafile had to be made suitable for analysis. In Appendix B the steps taken to prepare the data for the analyses are described. Since some of the attribute variables are categorical, they have to be recoded before the regression model can be estimated. In Table 4 the coding of the resulting new dummy coded variables is shown.

Table 4 - Dummy coding categorical variables

Attribute	Level	Coding	Dummy coded parameters		
Train	Always free	0	1	0	0
	Free off-peak and weekend travel	1	0	1	0
	Weekend free and off-peak discount	2	0	0	1
	Always discount	3	0	0	0
BTM	always discount	0	0		
	always free	1	1		
Shared car	€4,-/h + €0,29 / km	0	0		
	€3,-/h + €0,24 / km	1	1		
Bike	€1,- per trip up to 40 min	0	0		
	unlimited trips to 40 min	1	1		
Transferability	not transferable	0	0		
	transferable	1	1		
taxi/ride-hailing	0, 2, 4, 6		Continuous variable		
costs	50, 175, 300, 425		Continuous variable		

6.3 DIFFERENT TYPES OF TRAVELERS

A latent class cluster analysis was executed in order to find homogeneous groups in the sample with regards to their travel behavior. As was mentioned in section 3.2, latent class modelling assumes that each respondent belongs to a certain latent class. The goal of an LCA is to find a model with the smallest number of classes that explains all of the associations among the indicators.

To determine the most parsimonious model, first only the measurement model (without adding covariates) was estimated. This was done for the range between 0 and 10 clusters. In order to determine the number of appropriate classes, the AIC criterion, which takes into account both model fit and parsimony, was used.

The model with the smallest AIC number should be selected. As can be seen in Table 5 however, the AIC value keep decreases as the number of clusters increases. Hence, based on this global measure, an optimal model cannot be selected. Instead, one can look at a local measure, namely the bivariate residuals. If a BVR value that is larger than 3.84 (with on degree of freedom) remains between a pair of indictors, than the model does not adequately account for covariance between the pair of indicators.

Based on this indicator, a five-class model was found to be the most parsimonious model that could account for the associations between the variables.

After establishing the covariates were added to predict class membership. This was done by first adding all socio-demographics, and then backward eliminating insignificant parameters. This resulted in a model with the covariates age and household size, that were significantly affecting class membership. The insignificant parameters: employment situation, living environment, gender, income, and educational level did not turn out to be significantly affecting class membership. However, they were included as inactive covariates. This way the covariates do not influence the membership function, but their distributions are still reported in order to better interpret the profile output. Then, other mobility indicators were added. Only the availability of a seasonal public transport pass was found to significantly influence class membership. The standard R-squared statistic gives an indication of the portion of variability that is explained by the included covariates. In the final model, this yields a value of 0,8260 indicating that a significant amount of variability in class membership is explained by the included variables.

Table 5 - 1-10 cluster models statistical tests

	LL	**AIC(LL)**	**Npar**	**L^2**	**df**	**p-value**	**Highest BVR**
1-Cluster	-2186	4456	42	2233	161	0.00	122,21
2-Cluster	-2077	4254	50	2015	153	0.00	34,12
3-Cluster	-2046	4209	58	1954	145	0.00	22,93
4-Cluster	-2019	4171	66	1900	137	0.00	5,17
5-Cluster	-2000	4148	74	1861	129	0.00	**2,14**
6-Cluster	-1989	4142	82	1839	121	0.00	1,82
7-Cluster	-1970	4120	90	1801	113	0.00	2,23
8-Cluster	-1955	4106	98	1770	105	0.00	2,74
9-Cluster	-1944	4101	106	1750	97	0.00	4,08
10-Cluster	-1932	4092	114	1724	89	0.00	1,61

Table 6 - Within cluster distributions

	PT + bike	Car mostly	Bike + car	PT + car	Multimodal
Cluster Size	34%	22%	18%	16%	10%
Indicators					
Private car use					
Less than once a year	12%	0%	0%	0%	27%
1-5 days per year	9%	0%	0%	0%	13%
6-11 days per year	27%	0%	2%	4%	27%
1-3 days per month	**42%**	0%	24%	33%	**28%**
1-2 days per week	10%	0%	**49%**	**47%**	4%
3-4 days per week	1%	6%	22%	15%	0%
5-6 days per week	0%	33%	3%	1%	0%
(almost) every day	0%	**61%**	0%	0%	0%
Shared car use					
Less than once a year	**81%**	**94%**	**100%**	**85%**	27%
1-5 days per year	11%	5%	0%	10%	14%
6-11 days per year	6%	1%	0%	4%	**28%**
1-3 days per month	2%	0%	0%	1%	26%
1-2 days per week	0%	0%	0%	0%	4%
Train use					
Less than once a year	0%	23%	8%	0%	5%
1-5 days per year	0%	22%	13%	0%	10%
6-11 days per year	2%	**29%**	28%	1%	25%
1-3 days per month	13%	21%	**35%**	8%	**39%**
1-2 days per week	26%	4%	12%	20%	17%
3-4 days per week	**29%**	1%	2%	**29%**	4%
5-6 days per week	16%	0%	0%	20%	0%
(almost) every day	14%	0%	0%	22%	0%
BTM use					
Less than once a year	0%	21%	9%	0%	13%
1-5 days per year	2%	26%	17%	2%	21%
6-11 days per year	9%	**28%**	**29%**	10%	**30%**
1-3 days per month	24%	18%	**29%**	25%	25%
1-2 days per week	**28%**	5%	13%	**28%**	9%
3-4 days per week	15%	1%	3%	15%	2%
5-6 days per week	10%	0%	1%	9%	0%
(almost) every day	11%	0%	0%	10%	0%
Bicycle use					
Less than once a year	0%	8%	0%	1%	14%

1-5 days per year	0%	3%	0%	1%	5%
6-11 days per year	2%	18%	1%	6%	23%
1-3 days per month	3%	15%	2%	7%	**16%**
1-2 days per week	6%	15%	4%	11%	14%
3-4 days per week	11%	14%	9%	15%	12%
5-6 days per week	7%	4%	7%	7%	3%
(almost) every day	**71%**	**22%**	**77%**	**52%**	13%
Shared bicycle use					
Less than once a year	**26%**	**77%**	**75%**	**26%**	**25%**
1-5 days per year	15%	14%	14%	15%	14%
6-11 days per year	25%	7%	8%	25%	**25%**
1-3 days per month	22%	2%	2%	22%	23%
1-2 days per week	8%	0%	0%	8%	8%
3-4 days per week	3%	0%	0%	3%	3%
5-6 days per week	1%	0%	0%	1%	1%
Taxi_use					
Less than once a year	**42%**	**54%**	**59%**	**55%**	**24%**
1-5 days per year	32%	30%	28%	30%	30%
6-11 days per year	19%	13%	10%	12%	28%
1-3 days per month	6%	3%	2%	3%	16%
1-2 days per week	1%	0%	0%	0%	2%
Covariates	PT + bike	Car mostly	Bike + car	PT + car	Multimodal
Driving license					
No	22%	0%	3%	0%	10%
Yes	**78%**	**100%**	**97%**	**100%**	**90%**
Car posession					
Zero	**97%**	0%	0%	0%	33%
One	3%	30%	**84%**	**78%**	**52%**
Two	0%	**63%**	16%	22%	10%
More than two	0%	7%	0%	0%	5%
Car access					
Whenever I want	3%	**97%**	**49%**	36%	**61%**
In consulation with people within my household	5%	2%	48%	**58%**	24%
In consultation with people outside my household	**61%**	0%	3%	3%	0%
Never	31%	0%	0%	3%	15%
Seasonal public transport pass					
No	18%	**69%**	**55%**	12%	24%
Yes	**82%**	31%	45%	**88%**	**76%**
Travel cost compensation					
I don’t have travel costs	25%	5%	19%	3%	5%

Fully compensated	**40%**	**43%**	22%	**54%**	39%
Partially compensated	21%	38%	**30%**	22%	14%
Not compensated	15%	14%	29%	21%	**42%**
Mode traversing most km's					
BTM	6%	0%	3%	3%	0%
Bicycle	28%	0%	43%	0%	19%
Train	**62%**	2%	0%	**82%**	**43%**
Lease car	0%	29%	0%	3%	14%
Walking	4%	0%	5%	0%	0%
Private car	0%	**66%**	**48%**	12%	24%
Age groups					
15-25	27%	6%	6%	23%	0%
25-45	**61%**	**50%**	21%	**50%**	**100%**
45-65	11%	42%	**65%**	27%	0%
65-80	2%	3%	9%	0%	0%
80+	0%	0%	0%	0%	0%
Household size					
1	**63%**	14%	18%	6%	**28%**
2	21%	**39%**	**58%**	29%	24%
3	9%	11%	11%	28%	15%
4	6%	25%	13%	**34%**	19%
More than 4	1%	11%	0%	3%	14%
Employment situation					
Student	19%	2%	0%	12%	5%
Part-time work	22%	19%	15%	15%	10%
Full-time work	**40%**	**60%**	**39%**	**63%**	**43%**
Entrepreneur	7%	16%	30%	9%	19%
Unemployed	9%	0%	3%	0%	9%
Retired	1%	3%	13%	0%	14%
Residential type					
Rural	4%	**56%**	16%	16%	24%
Sub-urban	12%	9%	19%	25%	24%
Urban	**84%**	35%	**65%**	**60%**	**52%**
Gender					
Man	**68%**	**77%**	44%	**69%**	48%
Woman	32%	23%	**56%**	31%	**52%**
Income class					
1 (below 30.000 per year)	31%	0%	0%	3%	9%
2 (30.000 – 50.000 per year)	**45%**	25%	26%	6%	24%
3 (more than 50.000 per year)	24%	**75%**	**74%**	**91%**	**67%**

Table 6 shows the distributions of responses within each cluster. For ease of interpretation, a gradient color scale is laid over the cells to indicate where each cell value falls within that range. In the sections below, a description of the different clusters is given.

6.3.1 Cluster 1 – Public transport + bike users

The first and largest cluster consists of 33% of the sample. The people inside this group travel most often with bicycle and train. 64% of the cluster also makes use of BTM at least once a week. The group traverses most km's by train. It is thus not strange that 82% of the cluster possesses a seasonal public transport pass. Home to work travel costs are often (partially) compensated or non-existing. Car use is moderate in this cluster. This can be explained by the fact that most of the respondents in this cluster do not own a car, and only have access to a car in consultation with people outside of their household. This cluster also shows the lowest percentage of people having a driving license. When looking at shared mode use, most of the respondents in the cluster have experience with shared bicycles. Around 75% of the respondents use them, although not very frequently. Shared cars are used moderately. Around 20% of the respondents in this cluster use it a couple days per year. Even though this is limited, it is higher than the average of the sample. Taxi use is slightly above average compared to the sample, but most people in this cluster still only make use of it a couple of days per year. When looking at socio-demographics, the people in this group are the youngest compared to the rest of the sample, are more often man, and mostly live in single person households located in urban areas. Their job situation is often student or part-time worker and their income is mostly moderate.

6.3.2 Cluster 2 – Car mostly users

The second cluster, consisting of 22% of the respondents, can be considered car mostly users. They use the car almost daily, and public transport very infrequently. Almost everyone gets their travel costs at least partially compensated, and the none of the people in this cluster own seasonal public transport passes. 66% of the people in this cluster use their own car to travel most km's, and almost 30% use their lease-car. Respondents in this cluster have close to no experience with shared modes, and also infrequently makes use of the taxi. The bicycle is used regularly, however less frequently compared to the average of the sample. The people in this cluster mostly own at least two cars, live in more-person households in rural areas. They are overrepresented by men, of middle age, being full-time workers and having a high income.

6.3.3 Cluster 3 – Bike + car users

The third cluster can be characterized as bike + car users, and represent 18% of the sample. Bicycle is used most often, with 77% of the people in this group using it (almost) everyday. Next to that, private cars are used at least 1-2 days per week by 70% of the group. Most people traverse the largest share of their travelled km's by car (48%), and secondly bicycle (34%). Most people in this cluster make use of public transport 1-3 days per month or less. This group has close to no experience with shared modes, and also used taxi most infrequently. Car ownership in this group is usually one per household, hence they have always access to a car, or in consultation with people inside their household. The majority of the people in this cluster women, older than average, between the ages of 45-65, living in two people households in urban areas. They either work or are retired and belong to the higher income households.

6.3.4 Cluster 4 – Public transport + car users

The fourth cluster can be categorized as mostly public transport users, having easy access to car. The cluster consists of 16% of the entire sample. Of all groups, this group uses public transport most often, and also cover most of their km's by train. Even though most of the people own at least one car, and can access them whenever they want, they only use car 1-2 days per week or less,. Cycling is also done quite regulary. 52% cycles almost everyday. The group has some experience with shared modes, 33% uses shared bikes at least once a month, and 15% use car-sharing at least a couple days per year. Taxi use of this group is pretty average compared to the rest of the sample. The group has the highest share of public transport pass ownership, and highest share of people receiving full compensation for the work to home travel costs. They are a bit younger compared to the average. Are mostly full-time employed, living multiple person households in urban areas and having high incomes.

6.3.5 Cluster 5 – Multimodal innovative users

The final, and smallest group, with 10% of the sample can be considered the innovative mobility group. No single mode of transport is dominant. The largest share of people in this group travels most often by train, however with 20% using it at least once a week, this is below average compared to the rest of the sample. 90% of the cluster uses BTM 1-3 days per month or less. Both car use and bicycle use are lowest of the entire sample. This group shows the highest use of both shared bikes, shared cars, and taxi. 30% of this group uses shared cars 1-3 days per month or more, and around 36% of the group uses shared bikes at least 1-3 days per month. Most people in this cluster always have access to cars, and own one car. A relatively high share, 75%, of people have seasonal public transport passes. They are however usually not compensated for their travel costs. On average the people in this group are slightly older than average, live mostly in multiple-person households, have full-time jobs and can be found in all types of residential areas. Distribution of gender is quite equal, and they often belong to higher income classes.

6.3.6 Comparison to other research

A study by Molin, Mokhtarian, & Kroesen (2016) also performed a cluster analysis based on the reported mode frequency of different transport modes of people in the Netherlands. In this study, shared modes and taxi use were not included, hence the clustering was executed based solely on car, bike, train, and BTM use. The study also reported five clusters. These are: Car Multimodal (MM) (27%), Bike MM (24%), Bike + Car (18%), Car mostly (17%) and PT MM (14%). Looking at the results, similarities can be observed in the clusters, however cluster distributions differ somewhat.

The PT MM (resembling the PT + bike cluster found in this study) is smallest (14%) compared to the largest in this study (33%). This big difference can be explained by the relatively large share of students in the sample, receiving free public transport passes by the Dutch government. However, a large share of the people in this cluster are expected to be in the bike + MM cluster, which also shows resemblance with the PT + bike cluster.

Also a car mostly group was found with very similar characteristics in terms of travel behavior and socio-demographics compared to the car mostly group in this research. With a share of 17% it is a little smaller than the car mostly group in this study (22%). This could be explained by the overrepresentation of men, and car-owners in this study. The bike + car group found in the present study has a sample share of 18%. This group is thus equally large in both samples, and their characteristics also closely resemble each other.

A bike multimodal group was found, consisting of 24% of the sample. The characteristics of this group mostly resemble the PT + bike and the shared mobility groups from this study. It can thus be expected that some of the people in this cluster would belong to the shared mobility cluster if the use of shared modes would be included in the measurement model. The Car MM group (27%) is the largest in the sample. In this research a PT + car group was found that resembles this group to some extent (in terms of age, residential location and household size) However, the group is significantly smaller (16%). This could be due to the different indicator variables used in the studies, leading to a somewhat different classification.

6.4 Travel behavior change

Now that the different clusters are distinguished, and with it sub question four was answered, the results of the regression analyses can be presented. In this section sub-question 5: "What are the effects of MaaS bundle elements on travel behavior change of the different identified travelers in the Netherlands?" will be answered. The clusters that were classified in the previous section will function as input for this part of the analysis. However, since the dataset is already relatively sparse, and with dividing the dataset based on clusters an even smaller dataset remains (only about 80 observations in the case of cluster 5), the choice was made to first present the general results, based on the entire dataset. Afterwards, the analyses are executed for each cluster separately, and major differences are discussed.

Travel behavior change was measured on four different levels, ranging from travel behavior decisions on the short term, towards longer term decisions: (1) change in mode choice, (2) peak-hour avoidance, (3) total trip frequency, (4) car-shedding.

Firstly, in section 0 the results of the impacts of MaaS bundles on change in **mode use** are presented. As mentioned before, this was measured for seven different modalities, on an ordinal scale. Hence seven different ordinal regression models were estimated, to determine the total effects. Then, for each cluster separate regression models were estimated to investigate if differences exist between the clusters.

Secondly, in section 6.4.2 results of the impacts of MaaS bundles **peak hour avoidance** are presented. A binary logistic regression analysis was estimated to predict the influence of bundle attributes on the outcome.

Thirdly, in section 6.4.3 the results of the increase or decrease in the **total trip frequency** of the respondents are presented. This was measured on a five point ordinal scale, ranging from much less, to much more. Ordinal regression was also be used.

Fourthly and finally, in section 6.4.4 the results of the **car-shedding** are presented. Depending on the current situation of the respondent, the question was asked in three different ways.

6.4.1 Change in mode use

In the estimated models, change in mode use was set as the dependent variable. The nominal bundle attributes were included as factors and the continuous attribute (taxi) as covariate. The first step in interpreting the output is examining whether the estimated model provides a good fit. Four different tests as discussed in the methodology are presented. These tests are firstly the chi-square statistic, indicating whether the final model is a significant improvement compared to the baseline intercept-only model. A good fitting model has a statistically significant chi-square value. Next, the goodness-of-fit statistic indicates whether the observed data are consistent with the fitted model. A statistically insignificant chi-square value assumes a good model fit. Additionally, the Nagelkerke R-squared value gives an indication of the strength of association between the dependent variable an the predictor variable. Finally the test of parallel lines indicates whether the proportional odds assumptions holds for each outcome.

Then, the parameter estimates can be interpreted. The estimates can range between $-\infty$ and ∞. When the parameter is negative, the independent variable leads to higher odds of attaining a lower score on the dependent variable, compared to the influence of the reference category (since they are dummy coded). If the parameter is positive, the independent variable causes higher odds of attaining a higher score on the dependent variable compared to the reference category. For continuous variables, a positive value indicates that per unit increase in the independent variable, leads to a higher odds of attaining a higher score increase.

6.4.1.1 Expectations

Several expectations regarding the parameters to be estimated can be formulated. It is expected that mode-specific bundle attributes have a positive influence on the mode use for that same mode, since bundle elements are coded 'in a positive way' (i.e. a more favorable attribute received a higher level coding. For example: unlimited access to BTM is perceived as more favorable than 20% discount, hence unlimited access is coded as 1, and discount as 0). These are thus direct bundle element effects. For example, 'higher' levels of shared bikes will have a positive influence on the shared bike use. When looking at cross elemental effects, it is firstly expected that public transport attributes have a positive influence on each other meaning that a higher level of train would also lead to higher usage of BTM and vice versa. Next to that, a positive relation is expected to be found between train and shared-bike-, and taxi-use, because together they can complement each other on the entire leg of a trip, and therefore provide a substitute for car usage. Subsequently, it is expected that higher levels of all attributes lead to decreased usage of car. Conversely, higher levels of BTM and shared bikes are expected to lead to a decreased usage of bicycle because of their substitutability, and higher levels of BTM are also expected to decrease use of shared-bikes. Furthermore, higher levels of taxi are expected to decrease shared-bike- and BTM-use because of their substitutability. Transferability of taxi trips are expected to decrease taxi usage, because people would feel less need to deplete their credits before the end of the month.

Table 7 - Expected relations attributes and mode change

Expectation	Expected sign
Higher levels of train, more train use	+
Higher levels of BTM, more train use	+
Higher levels of taxi, more train use	+
Higher levels of train, more BTM use	+
Higher levels of taxi, lower levels of BTM use	-
Higher levels of BTM, more BTM use	+
Higher levels of shared car, more shared car use	+
Higher levels of train, lower levels of car-use	-
Higher levels of BTM, lower levels of car-use	-
Higher levels of shared car, lower levels of car-use	-
Higher levels of shared bike, lower levels of car-use	-
Higher levels of taxi, lower levels of car-use	-
Higher levels of train higher levels of shared bike use	+
Higher levels of BTM, lower levels of shared-bike use	-
Higher levels of taxi, lower levels of shared-bike use	-
Higher levels of shared bike, more shared bike use	+
Higher levels of BTM, lower levels of own bike use	-
Higher levels of shared-bikes, lower levels of own bike use	-
Higher levels of train, higher levels of own bike use	+
Higher levels of train, higher levels of taxi use	+
Higher levels of taxi, more taxi use	+
Transferable credits, less taxi use	-

In Figure 11, the expected relations are visualized. Positive expected relations are displayed with a green arrow, while negative expected relations are displayed with a red arrow.

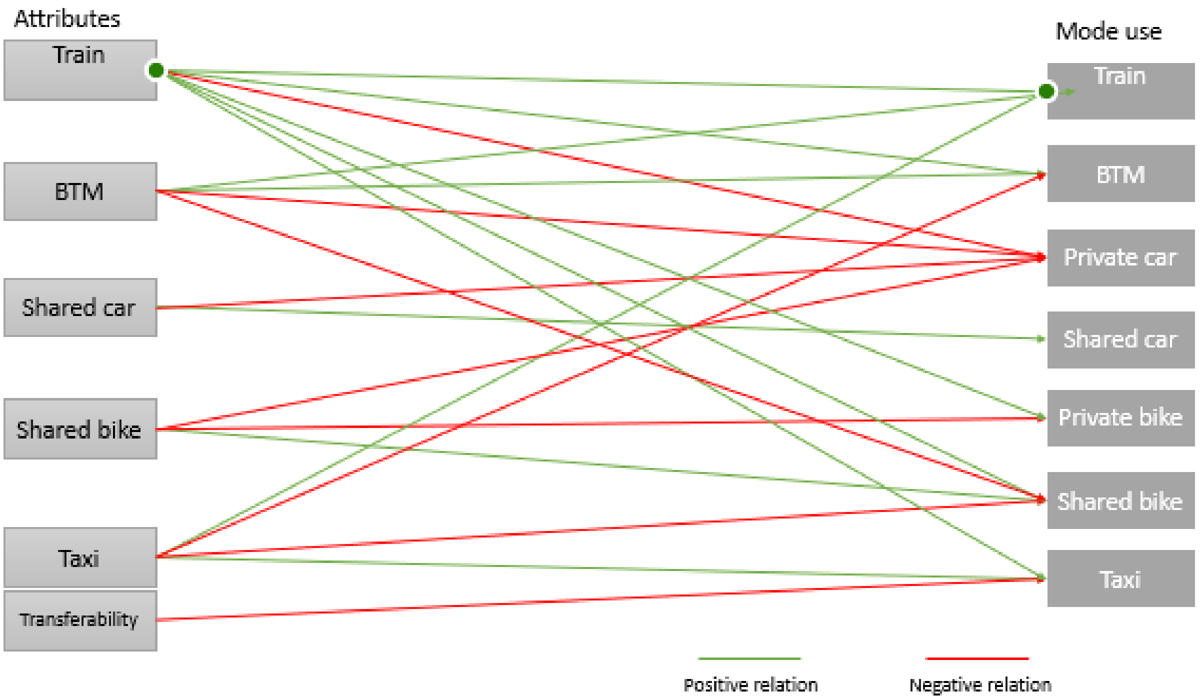

Figure 11 - Expectations relationships bundle attributes on change in mode use

6.4.1.2 Change in train use

Below, the results of change in mode choice for train are presented. The model fit test indicated a significant improvement in model fit compared to the null-model. The goodnesss-of-fit tests indicated a well-fitting model, and the assumption of proportional odds holds. The Nagelkerke R-squared is 0,185.

Table 8 - Case processing summary mode choice change train

	N	Percentage
Much less	29	3,6%
A little less	69	8,5%
The same	375	46,2%
A little more	253	31,2%
Much more	73	9,0%
N/A	12	1,5%

When looking at the output of the ordinal regression analysis, first the case processing summary is interesting to look at. As can be seen the distribution of responses is skewed towards the right, with most people indicating that they would not change their behavior, however more people would use the train more often compared to less often.

Table 9 - Parameter estimates mode choice change train

		Estimate	Wald
Threshold	Much less	-2,683	98,071
	A little less	-1,338	35,78
	The same	1,256	31,569
	A little more	3,461	184,575
	Much more	-	-
Train	Unlimited travel	**2,077**	88,099
	Free-off-peak + weekend	**0,787**	15,973
	Weekend-free + off-peak discount	**0,401**	4,19
	Always discount	0	.
BTM	Unlimited travel	**0,313**	3,859
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	-0,102	0,451
	4 euro per hour + 0,29 cents per kilomter	0	.
Shared bike	Unlimited trips up to 40 min	0,139	0,748
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	**0,083**	4,721
	Transferable	0,17	1,244
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

Looking at the parameter estimates, it can be seen that for all train bundle element levels, a significant and positive association is found with change in mode use for train. This is in line with expectations, and shows that these attribute levels increase the chance of attaining a higher score to mode change, hence increasing the chance to travel more often with train compared to the reference category, which is 'always discount'. The strongest effect is found for 'unlimited travel'.

The unlimited BTM attribute level is also found to have a significant and positive influence on change in mode use of train. This result shows that when 'unlimited BTM' is included as a bundle element, respondents have a tendency to travel more often with train. The suspected complementarity between BTM and train can thus be confirmed. It must be noted that the strength of the influence is lower than that of unlimited train however.

Furthermore a significant and positive relation is found between the number of taxi trips, and change in mode use of train. The strength of the effect is about similar to that of the unlimited BTM attributes. When four taxi trips are included, the effect on mode use of train about as strong as the inclusion of unlimited access to BTM. This further confirms the hypothesis that taxi and train can complement each other.

A change in the attribute levels of shared cars and transferability of credits does not have a significant influence on change in train use. For the following results it must thus be noted that they have to be interpreted carefully. The sign for shared cars is negative, indicating that a slight negative association between the inclusion of shared cars, and change in mode use of train could exists. Some train trips could thus be replaced by shared cars. Unlimited access to shared bikes shows a positive sign, hence could result in more train travel. This could be explained by the popular bicycle-train combination. The parameter for transferability is also positive. This could indicate that when credits can be taken towards the next month, respondents are less likely to replace train trips with taxi trips.

6.4.1.3 Change in BTM use

Below the results of the change in mode choice for train are presented. The estimated model was found to be significantly better than the intercept only model. The goodness of fit tests provided mixed results. The Nagelkerke R-square was 0,115, and the proportional odds assumption was met.

Table 10 - Case processing summary BTM

	N	**Percentage**
Much less	17	2,1%
A little less	45	5,7%
The same	447	56,4%
A little more	216	27,3%
Much more	67	8,5%

When looking at the case processing summary, also for change in mode choice for BTM, most people indicate that they would either remain their current behavior, or that they would increase it by a little in the case of receiving a MaaS bundle. This skewedness towards the right could be explained by the fact that the lowest bundle attribute level for BTM was 'always discount', which is more than nothing.

Table 11 - Parameter estimates BTM

		Estimate	Wald
Threshold	Much less	-3,053	94,006
	A little less	-1,672	48,925
	The same	1,637	48,301
	A little more	3,531	179,352
	Much more		
Train	Unlimited travel	-0,148	0,485
	Free-offpeak + weekend	0,032	0,025
	Weekend-free + offpeak discount	0,096	0,228
	Always discount	0	.
BTM	Unlimited travel	**1,424**	63,412
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	0,148	0,89
	4 euro per hour + 0,29 cents per kilomter	0	.
Shared bike	Unlimited trips up to 40 min	0,167	0,982
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	-0,034	0,703
	Transferable	0,12	0,561
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

When looking at the parameter values, only the unlimited BTM bundle attribute significantly influences change in BTM use, compared to the reference attribute. This relationship is found to be positive, i.e. the inclusion of this bundle element results in a higher level of BTM use, which is as expected. All other elements are found to have no significant effect on mode use of BTM. The hypotheses that the number of taxi trips would reduce, and access to rail would increase BTM use could thus not be confirmed.

The directions of the parameters are still interesting to present, but must be interpreted with caution. As for the positive sign of train attributes, it could be expected that train generally complements BTM, except in the case of having 'unlimited travel', only then some BTM trips could be replaced by trains. The inclusion of shared cars don't lead to lower levels of BTM use. Shared bikes seem to complement BTM rather than replace trips. The inclusion of taxi however could lead to a decrease in BTM usage, indicating that it could lead to some trips being replace by taxi. This effect decreases when credits are transferable.

6.4.1.4 Change in car use

Below, the effects of bundle elements on change in car use of are presented. The estimated model provided a significant improvement in fit over the intercept only model. From the goodness of fit test, the null-hypothesis must be rejected, indicating that the data fits the model well. The test of parallel lines also confirmed the proportional odds assumption. However, the Nagelkerke R-squared is with 0,044 very low, indicating that the strength of association between the variables is not very high.

Table 12 - Case processing summary car

	N	**Marginal Percentage**
Much less	26	3,8%
A little less	166	24,2%
The same	441	64,2%
A little more	39	5,7%
Much more	15	2,2%

When looking at the case processing summary, it can be seen that MaaS bundles have some potential to decrease car-usage, and at the same time (to a lesser extent) increase car usage. Most respondents however indicated that they would not change their behavior.

Table 13 - Parameter estimates car

		Estimate	Wald
Threshold	Much less	-3,893	147,77
	A little less	-1,562	36,014
	The same	1,955	53,098
	A little more	3,304	91,264
	Much more		
Train	Unlimited travel	**-0,601**	6,175
	Free-offpeak + weekend	-0,234	1,065
	Weekend-free + off-peak discount	-0,086	0,141
	Always discount	0	.
BTM	Unlimited travel	**-0,443**	5,219
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	-0,085	0,229
	4 euro per hour + 0,29 cents per kilometer	0	.
Shared bike	Unlimited trips up to 40 min	-0,228	1,484
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	-0,006	0,02
	Transferable	0,138	0,591
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

Looking at the impact of MaaS bundle elements on change in car use, it can be seen that unlimited access to public transport (both train and BTM) has the potential to reduce the number of car trips. The effect of unlimited train is stronger than that of BTM, which can be expected since car and train are both more attractive for longer distances.

It is noteworthy that the effects of cheaper access to shared cars does not significantly influence change in car usage. It thus seems that respondents do not perceive shared-cars at this tariff structure to be a viable alternative for private cars, or at least not cause them to travel less often with car. All other parameter signs are as expected, negative however.

6.4.1.5 Change in shared car use

The results of mode change for shared car are displayed below. The model fit test provided no significant improvement compared to the null-model. The goodness-of-fit however did reveal that the data fitted the model well. The proportional odds assumption was also met, but the Nagelkerke R-squared is with 2,7% very low.

Table 14 - Case processing summary shared car

Much less	**13**	**2,0%**
A little less	29	4,5%
The same	411	63,6%
A little more	178	27,6%
Much more	15	2,3%

The case processing summary indicates that MaaS bundles do have a tendency to increase shared-car usage by a little. Most people however indicated that they would not change their behavior. Only a few indicated that they would decrease their usage.

Table 15 - Parameter estimates shared car

		Estimate	Wald
Threshold	Much less	-3,258	78,599
	A little less	-2,031	49,782
	The same	1,555	31,69
	A little more	4,461	142,488
	Much more		
Train	Unlimited travel	0,192	0,58
	Free-off-peak + weekend	0,013	0,003
	Weekend-free + off-peak discount	0,183	0,62
	Always discount	0	.
BTM	Unlimited travel	0,257	1,744
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	**0,554**	9,187
	4 euro per hour + 0,29 cents per kilometer	0	.
Shared bike	Unlimited trips up to 40 min	0,119	0,366
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	0,058	1,585
	Transferable	0,174	0,92
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

The only bundle attribute level significantly affecting shared car usage was found to be the shared car attribute. This is in line with expectations. All other attributes were found to be insignificant, but all signs are positive. It thus seems that shared car usage would not replace any trips by other modes inside the MaaS bundle. They should rather be seen as complements.

6.4.1.6 Change in shared bike use

The results of change in shared bike use as a result of the different MaaS bundles are presented below. In terms of model fit, the estimated model provided a significant improvement compared to the intercept only model. The goodness-of-fit test however failed to reject the null-hypothesis, indicating the data does not fit the model well. Also the proportional odds assumption was violated. The Nagelkerke R-squared was 7%. The regression results thus have to be interpreted with caution.

Table 16 - case processing summary shared bike

	N	**Marginal Percentage**
Much less	27	3,7%
A little less	46	6,3%
The same	406	55,8%
A little more	194	26,7%
Much more	54	7,4%

Looking at the case processing summary, it can be seen that MaaS bundles do have the tendency to induce shared bike usage to some degree, however, in the majority of cases respondents indicated that they would not change their current behavior. Also in some cases, respondents indicated that they would use it less often.

Table 17 - parameter estimates shared bike

		Estimate	Wald
Threshold	Much less	-3,527	139,229
	A little less	-2,445	91,186
	The same	0,537	5,336
	A little more	2,465	89,415
	Much more		
Train	Unlimited travel	0,208	0,844
	Free-off-peak + weekend	-0,243	1,363
	Weekend-free + off-peak discount	-0,16	0,586
	Always discount	0	.
BTM	Unlimited travel	-0,232	1,758
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	-0,15	0,851
	4 euro per hour + 0,29 cents per kilometer	0	.
Shared bike	Unlimited trips up to 40 min	**1,04**	33,913
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	-**0,115**	7,984
	Transferable	0,294	3,246
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

Looking at the parameter estimates, it can be seen that the unlimited shared bike attribute has, as expected, a significant and large positive effect on shared bike usage. Taxi trips on the other hand have a significant negative effect on shared bike usage. This was also expected, and it thus means that the increase of the number of taxi trips leads to less tendency to use the shared bike.

All other variables were not found to have a significant effects on shared bike usage. It was expected that BTM would have a negative relation with shared bike usage, as they are both interesting egress alternatives in urban areas. The sign of the BTM attribute could confirm this hypothesis, but since the parameter is not significant, it cannot be accepted.

6.4.1.7 Change in own bike use

Below, the result of the regression analysis for change in mode choice for respondent's own bike are displayed. The final model was found to be significantly better than the null-model. The goodness-of-fit test also revealed that the data fitted the model well. The proportional odds assumption was met, but the Nagelkerke R-squared is with 3% very low.

Table 18 - Case processing summary own bicycle

	N	**Marginal percentage**
Much less	12	1,5%
A little less	59	7,4%
The same	662	83,5%
A little more	44	5,5%
Much more	16	2,0%

As can be seen in the case processing summary, the answers are normally distributed with almost all respondents indicated that they would not change their current bicycle behavior.

Table 19 - Parameter estimates own bicycle

		Estimate	Wald
Threshold	Much less	-4,676	122,833
	A little less	-2,81	73,206
	The same	2,148	47,171
	A little more	3,54	87,408
	Much more		
Train	Unlimited travel	0,246	0,67
	Free-off-peak + weekend	0,005	0
	Weekend-free + off-peak discount	0,245	0,788
	Always discount	0	.
BTM	Unlimited travel	-0,382	2,687
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	-0,022	0,011
	4 euro per hour + 0,29 cents per kilometer	0	.
Shared bike	Unlimited trips up to 40 min	**-0,664**	7,849
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	0,037	0,48
	Transferable	-0,082	0,145
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

The only significant effect found to decrease own bicycle usage was the inclusion of unlimited use of shared bikes. The directions of the insignificant parameters are all positive except that of BTM. This thus might indicate that unlimited use of BTM could result in a lower use of people's own bicycle. The strength of the parameters is the lowest compared to all other modes, indicating that it is the mode that is least affected by MaaS bundles.

6.4.1.8 Change in taxi use

Below the results of the regression analysis on change in mode choice for taxi are displayed. The model was found to perform significantly better than the null model. The data however does not fit the model well in terms of goodness-of-fit. The test of parallel lines confirmed the proportional odds assumption, and the Nagelkerke R-squared is 14,2% .

Table 20 - Case processing summary taxi/uber

	N	**Marginal percentage**
Much less	19	2,7%
A little less	22	3,1%
The same	396	55,5%
A little more	220	30,9%
Much more	56	7,9%

Looking at the case processing summary, it can be seen that MaaS bundles have more tendency to increase taxi usage, rather than decrease it. The majority however does not indicate that they would change their behavior.

Table 21 - Parameter estimates taxi/uber

		Estimate	Wald
Threshold	Much less	-2,838	78,079
	A little less	-2,019	54,651
	The same	1,555	38,855
	A little more	3,713	167,448
	Much more		
Train	Unlimited travel	0,349	2,259
	Free-offpeak + weekend	-0,005	0,001
	Weekend-free + offpeak discount	-0,086	0,158
	Always discount	0	.
BTM	Unlimited travel	-0,191	1,084
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	-0,069	0,169
	4 euro per hour + 0,29 cents per kilomter	0	.
Shared bike	Unlimited trips up to 40 min	0,103	0,333
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	**0,332**	56,756
	Transferable	0,13	0,588
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

Looking at the parameter estimates, as expected, the increase of the number of included taxi trips leads to the increase in taxi-use. Interesting to note is that the transferability of taxi trips to the next month does not significantly impact the tendency to use taxi. The insignificant parameters show expected signs for BTM, meaning that including unlimited usage of BTM could decrease taxi usage. For unlimited train travel, the opposite is true. This could indicate that the train-taxi combination could be an interesting one. Shared car and bike seems to have almost no impact on taxi-usage.

6.4.1.9 Summary of change in mode use

Below, an overview of the expected relations and corresponding results is given. As can be seen, most expectations hold, however, many are not statistically significant. It is difficult to tell whether this is due to the fact that there is no relation between the variables, or it is due to lower statistic power of these models because of the sparsity of data. From this overview, no conclusions can be drawn about the impact of the effects. In chapter 7 the impacts will be further explored by applying the models to different scenarios.

Table 22 - Overview of expectations and results

Expectation	Expected sign	Estimated sign	Significant	Expectation hold?
Higher levels of train, more train use	+	+	Yes	Yes
Higher levels of BTM, more train use	+	+	No	Yes
Higher levels of taxi, more train use	+	+	Yes	Yes
Higher levels of train, more BTM use	+	Mixed	No	No
Higher levels of taxi, lower levels of BTM use	-	-	No	Yes
Higher levels of BTM, more BTM use	+	+	Yes	Yes
Higher levels of shared car, more shared car use	+	+	Yes	Yes
Higher levels of train, lower levels of car-use	-	-	Yes	Yes
Higher levels of BTM, lower levels of car-use	-	-	Yes	Yes
Higher levels of shared car, lower levels of car-use	-	-	No	Yes
Higher levels of shared bike, lower levels of car-use	-	-	No	Yes
Higher levels of taxi, lower levels of car-use	-	+	No	No
Higher levels of train higher levels of shared bike use	+	Mixed	No	No
Higher levels of BTM, lower levels of shared-bike use	-	-	No	Yes
Higher levels of taxi, lower levels of shared-bike use	-	-	Yes	Yes
Higher levels of shared bike, more shared bike use	+	+	Yes	Yes
Higher levels of BTM, lower levels of own bike use	-	-	No	Yes
Higher levels of shared-bikes, lower levels of own bike use	-	-	Yes	Yes
Higher levels of train, higher levels of own bike use	+	+	No	Yes
Higher levels of train, higher levels of taxi use	+	Mixed	No	No
Higher levels of taxi, more taxi use	+	+	Yes	Yes
Transferable credits, less taxi use	-	-	No	Yes

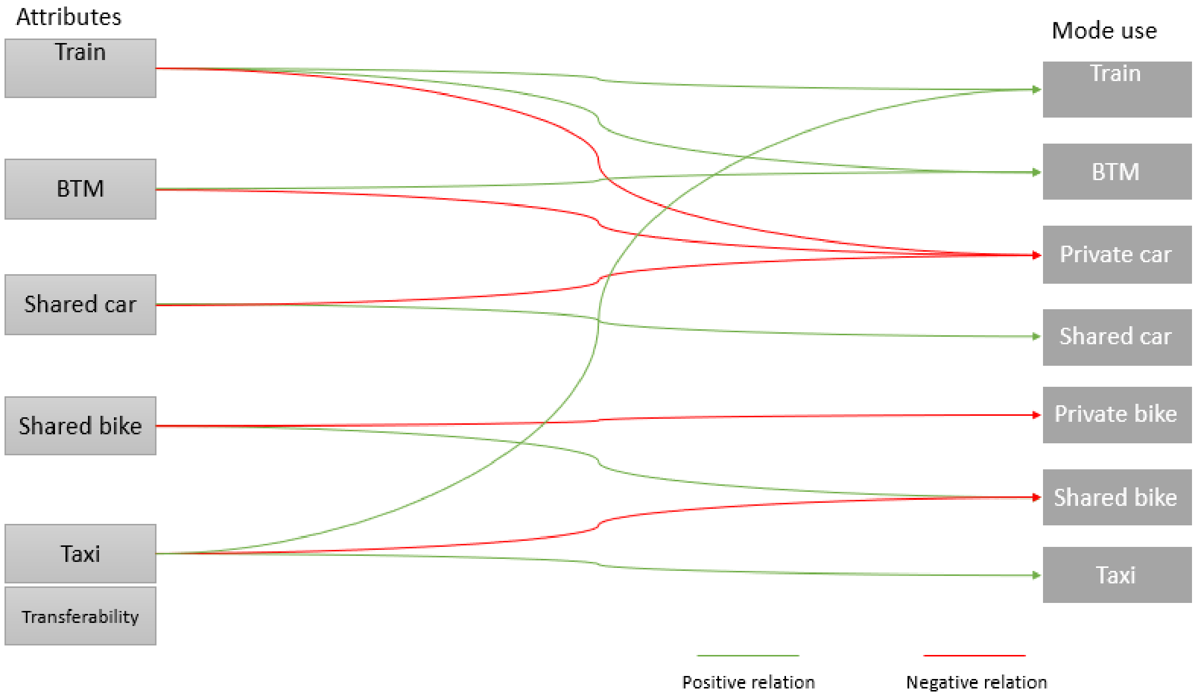

Figure 12 - Significant effects bundle elements on mode use

6.4.2 Total trip frequency

Now that the influence of the bundle attributes on change in mode use has been determined, the impacts of bundle attributes on total trip frequency can be investigated. This has been examined by asking people whether they would increase or decrease their total number of trips travelled in a typical week as a result of a given MaaS bundle. The effect was measured on a similar five point ordinal scale as the change in mode use part. Ordinal regression analysis was thus used again, for which change in total trip frequency was set as the dependent variable, and the bundle elements as the independent variables. The expectation is that by granting people easier access to different modalities, total trip frequency will be induced.

Table 23 - Case processing summary total trip frequency

	N	**Marginal Percentage**
Much less	16	2,0%
A little less	41	5,1%
The same	524	65,3%
A little more	208	25,9%
Much more	14	1,7%

From the case processing summary the first signs can be seen that MaaS bundles might have a tendency to induce trips to a larger extent rather than to reduce the total number of trips. At first sight, this is undesirable from a transport policy perspective. However, it depends if the extra number of trips are the result of more multi-modal travel at the expense of unimodal travel, or if they are truly extra trips made because of the increased access to mobility.

Table 24 - Parameter estimates total trip frequency

		Estimate	Wald
Threshold	Much less	-2,996	83,822
	A little less	-1,653	43,348
	The same	2,12	68,635
	A little more	5,293	206,033
	Much more		
Train	Unlimited travel	**1,225**	27,891
	Free-off-peak + weekend	0,354	2,593
	Weekend-free + off-peak discount	0,235	1,131
	Always discount	0	.
BTM	Unlimited travel	**0,546**	8,629
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	0,218	1,677
	4 euro per hour + 0,29 cents per kilometer	0	.
Shared bike	Unlimited trips up to 40 min	0,155	0,758
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	0,034	0,672
	Transferable	0,028	0,027
	Not transferable	0	.
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

When looking at the parameters, the only significant effects are found for unlimited access to train and unlimited access to BTM. Both effects are positive, meaning that they lead to an increase in the number of trips travelled compared to the reference attributes. Unlimited train travel has a stronger effect than BTM. All other variables have no significant effect. They are all positive however, indicating that they could result in induced travel. It thus seems that unlimited access to public transport, and especially train results in people making additional trips. In general MaaS bundles do not contribute to a lower number of trips.

6.4.3 Peak-hour avoidance

In addition to change in frequency of travel, it was measured whether or not people would travel more outside of peak-hours given certain bundles. This is interesting from a transport policy perspective since a big reason for congestion and crowding is the simultaneous use of transport. If people would travel more outside of peak-hours, a better distribution could be accomplished which reduces the need for additional capacity. The dependent variable was measured on a binary scale, hence binary regression analysis was used.

The model provided a significant improvement in model fit compared to the null-model. The Nagelkerke R square is 8,5%.

Table 25 - Case processing summary peak-hour avoidance

	N	**Marginal percentage**
No	580	71%
Yes	232	29%

As can be seen from the case processing summary, in almost 30% of the observations respondents indicated that they would be willing to travel more outside of peak hours. This is quite a large share, indicating that there is most likely room for improvement in the distribution of travelers over time.

Table 26 - Peak hour avoidance

		Estimate	Wald
	Constant	-1,136	14,678
Train	Unlimited travel	0,283	1,645
	Free off-peak and weekend	**0,602**	7,629
	Weekend free and off-peak discount	**-0,955**	11,566
	Unlimited discount	0	.
BTM	Unlimited travel	0,009	0,002
	Unlimited discount	0	.
Shared car	3 per hour + 0,24 per km	0,187	1,039
	4 per hour + 0,29 per km		
Shared bike	Unlimited trips up to 40 min	0,016	0,007
	1 euro per trip up to 40 min		
Taxi	Taxi trips	-0,012	0,061
	Transferability	-0,164	0,888
	Not transferable	0	0
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

As can be seen, there are two attributes levels found to significantly affect peak-hour avoidance. In the case of unlimited off-peak and weekend travel these results are positive, hence people would travel more outside of peak-hours. In the case of off-peak discount, whereby people thus still have to pay 60% of the original ticket price, people would decrease their off-peak travelling. The negative effect is even stronger than the positive effect indicating that a mere discount on off-peak travel is not enough to discourage people from peak hour travelling.

From these results, it cannot be concluded if the people that indicate to reduce their peak-hour traveling are substituting their train trips in the peak hours, or car trips, or any other modality.

6.4.4 Car-shedding

Below, the results of car-shedding will be presented. The potential of MaaS bundles to offer an alternative for car ownership was examined after each shown bundle. Each respondent thus received four car-shedding questions. Depending on the current situation of the respondent, different questions were asked. Three different respondents were classified based on previously answered questions and accordingly channeled to different questions. These were: (1) respondents currently owning at least one car, (2) respondents owning a lease-car, (3) respondents not owning a car. The first group was asked whether they would be willing to get rid of none, one, or multiple cars if they received the given bundle. The second group was asked whether or not they would still want their lease-car if they received the bundle. The final group was asked whether or not they think in the future a (first or second) car would still be bought if they received that bundle.

Expectations are that lease car owners are least willing to get rid of their car, since they only pay partially have to pay for it, and use it a lot. Private car owners are expected to be more willing to shed a car since they are responsible for a larger part of the costs. Especially for a second car MaaS is expected to offer a solution, since these are often much less used. Non car-owners are expected to be most willing to reduce future car ownership.

Table 27 - Case processing summary car-shedding

Get rid of car	
No	83,4%
I would be willing to get rid of my second car	15,1%
I would be willing to get rid of my only, or all my cars	1,5%
Need car in future	
Yes	38,6%
I would not need a second car	17,6%
I would not need a car at all	43,8%
Lease car	
I would not need my lease car anymore	2,8%
I would still need a lease-car	97,2%

Looking at the case processing summary, it can be seen only 1,5% of the people owning a car indicated that they would get rid of their only, or all their cars. This almost negligible effect shows the (perception of) car dependence people have A somewhat larger percentage (15,1%) indicated that they would be willing to get rid of their second car. It thus seams that MaaS may only offer a viable alternative for shedding a second car.

A similar effect was found for lease-car owners. Only 2,8% of these respondents indicated that a MaaS bundle could replace the need to own a lease-car. Due to the lack of data, regression analyses could therefore not be executed to explore the bundle attribute influence.

Looking at non car-owners, the results are somewhat different. In the majority of cases (43,8%), the respondents believe that they would not need a car at all, if they would receive the MaaS bundle. In quite a large percentage (38,6%) of the cases however, respondents indicated that they would still need a car in the future. This could indicate that a large percentage of the people in this group are not non car-users by choice, but do so because of a lack of resources.

Various regression models were estimated to determine the influence of bundle attributes on car-shedding for both lease-car owners, and private car owners, however no significant results of bundle attributes on the decision to get rid of a (second) car have been found. Car-shedding thus seems to be a choice that is not influenced by the type of bundle, but rather a consideration that is already present within people.

For the group that does not yet have a car, significant results have been found after combining the dependent variable answers to a binary option namely: (1) MaaS is an alternative for car ownership (in the case of the answers: “I would not need a car at all”, and “I would not need a second car”) and (2) Maas is not an alternative for car-ownership (in the case of “I would still need a car in the future”).

A binary logistic regression model could be estimated. The results are presented in the table below.

Table 28 - MaaS as alternative for car ownership for non-car owners

		Estimate	Wald
Constant		0,217	0,49
Train	Unlimited travel	**0,746**	7,1
	Free off-peak and weekend	0,277	1,22
	Weekend free and off-peak discount	0,065	0,068
	Unlimited discount	0	.
BTM	Unlimited travel	0,206	0,882
	Unlimited discount	0	.
Shared car	3 per hour + 0,24 per km	-0,071	0,114
	4 per hour + 0,29 per km		
Shared bike	Unlimited trips up to 40 min	0,016	0,007
	1 euro per trip up to 40 min		
	Taxi trips	-0,003	-0,003
	Transferability	-0,164	0,888
	Not transferable	0	0
Parameter is statistically significant at 95% confidence level when Wald > 3,84			

As can be seen, the only bundle attribute level that contributes to MaaS being an alternative for car-ownership among the people that do not own a car, is the inclusion of unlimited access to trains. This result is in line with the general belief that public transport should form the backbone of MaaS.

6.5 CLUSTER DIFFERENCES TRAVEL BEHAVIOR CHANGE

Now that the effects of MaaS bundle elements on all data is estimated, the results per cluster will be discussed. Based on the membership model as obtained by the LCA, the respondents were allocated to the cluster that they had the highest probability belonging to. This was executed by using the posterior membership classification function in LatentGold, and then exporting this dataset to SPSS. The datafile was then split based on the cluster variable, hence 5 separate files were established. Each analysis was then executed separately per cluster. It must be noted that a classification error of roughly 3% has to be taken into account. Hence, some cases might be wrongly classified, leading to a slight margin that has to be taken into account when interpreting the results.

Since the number of observations per cluster are much lower in these analyses, statistical power of these models is much lower. Therefore, only attribute parameters that were previously found to be significant and parameters that have now become significant will be discussed.

6.5.1 Change in mode use for different clusters

Several expectations with regards to the cluster differences in terms of travel behavior change can be formulated. Since using MaaS would require a behavioral shift towards more multi-modal travel, and therefore also the use of public transport and more novel services such as car-sharing it is expected that people that have more experience with such services have a higher tendency to change their behavior in that direction. Below, an overview is given of the amount of 'experience' people have with certain modes. When people have a 'low' level of experience with a certain mode, a positive change in that direction is not expected. When people have a 'medium' level of experience with a certain mode, a positive effect can be expected. When people have a 'high' level of experience, depending on whether or not the bundle attribute provides them with 'enough' access to the transport mode, they can either decrease, increase or stay with their current behavior.

Table 29 - Level of experience with different transport modes

Experience with modes	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Rail	high	low	medium	high	medium
BTM	high	low	medium	high	medium
Car	low	high	medium	medium	low
Bike	high	medium	high	high	medium
Shared bike	High	Low	Low	High	high
Shared car	Medium	Low	Low	Medium	high
Taxi	Medium	Low	Low	Low	high

6.5.1.1.1 Cluster differences train use

In the general model, statistically significant effects of bundle attributes and change in train use were found between the attributes for train and taxi. Therefore, the differences between the clusters for the effects of these attributes will be discussed. In Table 30 the result of the regression models for change in mode use of the different clusters is shown.

Table 30 - Cluster differences mode use train

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-2,749	36,871	0	.	-4,134	14,595	-1,776	8,985	-3,079	0,694
	A little less	-1,223	11,127	-1,968	14,658	-2,29	15,647	-0,674	1,476	-2,236	0,368
	The same	1,132	9,459	1,028	4,502	1,161	5,727	2,32	14,491	0,685	0,035
	A little mo	3,219	60,775	3,258	35,302	3,903	44,673	4,52	39,967	3,894	1,048
Threshold	Much more										
	Unlimited	**2,791**	49,444	**1,696**	12,243	**1,35**	7,472	**3,021**	28,483	0,511	0,028
	Free-offpe	**0,896**	7,333	0,521	1,406	**1,038**	4,43	0,52	0,981	1,178	0,295
	Weekend-f	0,722	4,851	0,382	0,748	0,303	0,431	-0,313	0,376	0,469	0,148
Train	Always disc	0	.	0	.	0	.	0	.	0	.
	Unlimited	-0,135	0,25	0,597	2,699	**0,826**	4,874	-0,143	0,102	-0,707	0,364
BTM	Always disc	0	.	0	.	0	.	0	.	0	.
	3 euro per	-0,149	0,363	-0,25	0,573	0,349	0,967	-0,175	0,171	-0,322	0,019
Shared car	4 euro per	0	.	0	.	0	.	0	.	0	.
	Unlimited	0,437	2,282	0,017	0,002	-0,235	0,345	0,375	1,008	1,44	0,913
Shared bike	1 euro per	0	.	0	.	0	.	0	.	0	.
	Taxi trips	**0,054**	7,449	0,174	0,42	0,003	0,001	0,028	0,077	-0,353	0,584
	Transferab	0,624	2,185	0,051	0,023	0,001	0,005	0,229	0,281	-0,502	0,335
Taxi	Not transfe	0	.	0	.	0	.	0	.	0	.

Looking at the parameters related to the train attribute, it can be seen that the largest effect for the unlimited attribute level are found within cluster 4 and 1. The people in these clusters have a lot of experience with train already, and therefore it was expected that they would be more likely to change their behavior. Interesting to note is that even though cluster 2 has the least amount of experience with train travel, they would still increase their train use substantially when granted with unlimited access to train. Cluster 3 has a little more experience with train than cluster 2, but is nonetheless less likely to increase their train compared to cluster 3. The least strong effect is found for cluster 5.

Cluster 3 and 5 would however increase their train travel mostly when receiving free off-peak and weekend free train travel compared to the other clusters, indicating that they might be more flexible in terms of their departure time choices. For cluster 5 this result is rather strange, since the attribute level leads to a larger effect than the more favorable bundle attribute 'unlimited access'. It could however be that the low statistical power of the model due to the small size of the cluster has lead to this odd result.

A negative effect is found for cluster 4 when receiving weekend free + off-peak discount. This group would thus decrease their train travel. This might be because they execute their daily commute by train, and are less flexible in terms of departure time choice.

Looking at the parameters related to the taxi attribute, it can be seen that the largest increase in train travel as a result of an increasing number of taxi trips can be expected from people in cluster 2. These are the strict car users, which could mean that they might consider train use a viable alternative for car trips when their access or egress can be made with a taxi. People in cluster 1 also increase their train usage as a result of an increasing number of taxi trips included in their MaaS bundle.

An effect that has now become significant is found for the unlimited BTM attribute. People in cluster 3 would increase their train use as a result of this. The complementarity of these modes is thus apparent for the people in this cluster, but not for the people in the other clusters.

6.5.1.2 Cluster differences BTM use

In the regression model on all data, only the BTM attribute was found to significantly influence BTM use. Therefore the differences between the effects of this attribute for the different clusters will be discussed.

Table 31 - Cluster differences mode use BTM

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-2,677	32,893	.				-3,338	17,688	0,112	0,001
	A little les	-1,46	14,622	-2,619	11,732	-2,855	21,615	-1,831	8,833	1,254	0,115
	The same	1,453	14,45	2,111	9,261	0,894	3,6	2,091	10,253	4,451	1,415
	A little mo	3,188	58,32	3,974	28,307	3,826	38,098	3,64	27,002	.	.
Threshold	Much more										
	Unlimited	**-0,738**	4,101	0,404	0,625	0,126	0,069	0,119	0,056	1,427	0,215
	Free-offp	-0,083	0,063	-0,017	0,001	0,34	0,482	-0,101	0,034	0,58	0,069
	Weekend	-0,004	0	0,544	1,191	0,221	0,234	-0,401	0,507	0,799	0,411
Train	Always di	0	.	0	.	0	.	0	.	0	.
	Unlimited	**1,946**	41,118	**1,676**	13,955	0,318	0,751	**2,009**	13,265	1,537	1,635
BTM	Always di	0	.	0	.	0	.	0	.	0	.
	3 euro pe	0,071	0,08	0,158	0,182	0,17	0,235	0,395	0,752	1,544	0,413
Shared car	4 euro pe	0	.	0	.	0	.	0	.	0	.
	Unlimited	-0,027	0,009	0,607	2,032	0,125	0,096	-0,126	0,101	-0,624	0,165
Shared bik	1 euro pe	0	.	0	.	0	.	0	.	0	.
	Taxi trips	**-0,025**	0,147	-0,08	0,654	-0,001	0	-0,032	0,088	0,333	0,521
	Transferal	0,115	0,202	-0,364	0,837	0,165	0,221	-0,191	0,163	-0,673	0,579
Taxi	Not transf	0	.	0	.	0	.	0	.	0	.

Looking at this BTM attribute, the largest effect on increase in BTM use occurs in cluster 4 and 1. These are the clusters that already often use PT, and therefore the effect was expected. Interesting to see is that the effect of the BTM attribute on increasing BTM use is also relatively strong in cluster 2; the car-mostly user group. In cluster 5, currently not using BTM a lot, the lowest effect is found.

For cluster 1, also the inclusion of unlimited train travel has led to a significant decrease in BTM use. This group, that is already travelling a lot with PT might thus substitute some BTM trips for train trips in the case of having unlimited access to trains.

6.5.1.3 Cluster differences car use

In the regression model estimated on all data, the significant effects that were found to influence car use were unlimited access to train and BTM, and the shared car attribute. Therefore the differences between the effects of this attribute for the different clusters will be discussed.

Table 32 - Cluster differences mode use car use

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-3,944	36,699	-4,333	31,292	-3,873	38,404	-4,884	26,771	-1,711	0,22
	A little les	-1,945	12,67	-1,491	6,243	-1,14	4,97	-2,182	11,345	-0,218	0,004
	The same	2,054	13,592	2,489	14,644	4,346	15,963	1,523	6,104	2,171	0,353
	A little mo	3,916	21,078	4,738	17,149	.	.	2,846	16,99	2,972	0,657
Threshold	Much more										
	Unlimited	-0,533	1,005	-0,311	0,376	**-0,979**	3,896	**-1,188**	4,243	-0,224	0,006
	Free-offp	-0,547	1,377	-0,253	0,271	-0,611	1,458	0,715	1,555	-0,022	0
	Weekend	-0,175	0,132	-0,58	1,496	-0,075	0,024	0,769	1,87	1,242	0,871
Train	Always di	0	.	0	.	0	.	0	.	0	.
	Unlimited	-0,425	1,088	**-0,798**	4,002	-0,25	0,425	0,293	0,345	-0,659	0,252
BTM	Always di	0	.	0	.	0	.	0	.	0	.
	3 euro per	0,172	0,219	-0,139	0,154	-0,145	0,156	-0,562	1,496	-0,164	0,005
Shared car	4 euro per	0	.	0	.	0	.	0	.	0	.
	Unlimited	-0,293	0,496	0,237	0,344	-0,258	0,397	-0,662	2,312	0,828	0,244
hared bik	1 euro per	0	.	0	.	0	.	0	.	0	.
	Taxi trips	-0,028	0,093	0,058	0,393	-0,055	0,346	-0,058	0,289	0,194	0,183
	Transferal	0,136	0,138	0,101	0,076	0,249	0,454	0,489	1,072	-0,467	0,21
Taxi	Not transf	0	.	0	.	0	.	0	.	0	.

When looking at the effects of bundle attributes on car use for each cluster specifically it can be seen that the largest decrease in car use as a result of the train bundle element takes place in cluster 4. Cluster 4 is the PT + car group. This would thus mean this group is most willing to substitute car-trips by train trips, which is to be expected since they have experience with train travel already, and next to that use their car. Also cluster 3; the Bike+car group, is likely to reduce car use as a result of the inclusion of the unlimited train attribute. The least strong effects are in the strict car user group, cluster 2, and the shared mode group, cluster 5.

When looking at the BTM attribute, it can be seen that the strongest negative effect is found for cluster 2, the strict car users. This is quite an interesting result, since it indicates that the inclusion of BTM contributes to a larger degree to the decrease in car-use compared to train for the people in this cluster. This could indicate that shorter car trips might be more easily substituted with BTM, rather than longer car trips with train. No new attributes that were previously insignificant have become significant.

6.5.1.4 Cluster differences shared car use

In the general model, the only significant parameters were found for the car-sharing attribute.

Table 33 - Cluster differences mode use shared car

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-3,596	26,331	-4,312	12,91	-3,289	19,661	-3,411	9,072	16,158	81,707
	A little les	-1,988	16,84	-2,473	10,022	-2,702	16,504	-1,393	4,189	17,013	94,469
	The same	1,178	6,724	1,69	5,251	1,23	4,497	3,204	18,452	19,685	128,413
	A little mo	4,698	48,709	4,108	21,9	3,522	24,024	5,889	32,886		
Threshold	Much more										
	Unlimited	0,366	0,7	0,141	0,052	0,555	0,977	-0,05	0,006	**0**	203,329
	Free-offp	0,134	0,116	0,308	0,313	-0,033	0,003	0,563	0,759	**0**	144,081
	Weekend	0,071	0,033	0,376	0,469	0,13	0,058	0,712	1,204	1,167	0,791
Train	Always di	0	.	0	.	0	.	0	.	0	.
	Unlimited	0,282	0,755	-0,088	0,037	-0,111	0,064	**1,153**	4,057	-0,53	0,188
BTM	Always di	0	.	0	.	0	.	0	.	0	.
	3 euro per	**0,711**	5,484	0,305	0,546	0,606	2,192	0,131	0,065	18,63	.
Shared car	4 euro per	0	.	0	.	0	.	0	.	0	.
	Unlimited	0,01	0,001	0,128	0,07	-0,167	0,133	0,185	0,129	1,453	0,637
Shared bik	1 euro per	0	.	0	.	0	.	0	.	0	.
	Taxi trips	0,053	0,465	0,107	0,572	-0,009	0,007	0,177	1,871	0,25	0,234
	Transferab	-0,268	0,793	0,005	0	-0,032	0,006	-0,19	0,131	-1,151	1,406
Taxi	Not transf	0		0	.	0	.	0	.	0	.

When looking at the results of the regression analyses for the different clusters, it can be seen that people in cluster 1 would increase their shared car usage mostly as a result of cheaper access to shared cars. The people in this cluster have already a 'medium' level of experience with shared cars, so this result was expected. Cluster 3 follows cluster 2 in terms of increasing mode use, which is interesting because they have close to no experience with shared cars. Cluster 4 on the other hand has some experience with shared cars, but barely increases its usage as a result of the inclusion of the cheaper access. This could be due to the fact that in the MaaS proposition for this research the shared car attribute was based on B2B car-sharing provider Greenwheels, whereas P2P car-sharing providers like Snappcar are often cheaper. Perhaps the people with some experience with car-sharing have experience with P2P car-sharing and therefore know that it could be cheaper. Cluster 2 shows a medium increase in shared car use, which is positive since they have no experience with it. Unfortunately no reliable results for cluster 5 are obtained.

6.5.1.5 Cluster differences shared bike use

In the general model, significant effects were found between shared bike use, and the attributes taxi and shared bikes.

Table 34 - Cluster differences mode use shared bike

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-4,403	56,184	.	.	-2,598	18,964	-2,995	18,862	-6,076	2,747
	A little les	-2,585	37,436	-3,731	27,96	-2,07	13,904	-1,894	9,77	-5,695	2,427
	The same	0,084	0,049	0,245	0,188	1,06	4,183	1,333	5,105	-2,894	0,65
	A little mo	1,584	15,957	2,889	18,11	4,007	27,697	3,536	26,202	-0,431	0,014
Threshold	Much more										
	Unlimited	0,404	1,083	0,502	0,793	0,048	0,009	-0,07	0,018	-2,453	0,671
	Free-offp	-0,352	1,048	-0,578	1,329	0,094	0,031	-0,016	0,001	-2,046	0,916
	Weekend	-0,159	0,213	-0,263	0,274	-0,247	0,232	0,215	0,162	-0,994	0,666
Train	Always di	0	.	0	.	0	.	0	.	0	.
	Unlimited	**-0,641**	4,833	-0,195	0,218	0,242	0,355	0,221	0,229	-1,514	1,712
BTM	Always di	0	.	0	.	0	.	0	.	0	.
	3 euro per	-0,003	0	-0,614	2,66	0,052	0,018	-0,34	0,608	-2,067	0,794
Shared car	4 euro per	0	.	0	.	0	.	0	.	0	.
	Unlimited	**1,271**	16,277	**1,33**	8,461	0,419	0,894	**1,57**	13,557	1,644	1,239
hared bik	1 euro per	0	.	0	.	0	.	0	.	0	.
	Taxi trips	-0,116	3,077	**-0,191**	4,063	-0,07	0,495	-0,126	1,478	-0,47	1,101
	Transferab	**-0,574**	4,683	-0,211	0,308	0,044	0,013	-0,27	0,369	-0,302	0,127
Taxi	Not transf	0	.	0	.	0	.	0	.	0	.

Looking at the different clusters it can be seen that all clusters would increase their shared bike use with unlimited access. The strongest effects of increasing bike use as a result of unlimited access to bike-share are found within cluster 5, which is already using shared-bikes most often compared to the other clusters. The least strong effect is found in cluster three, which are travelers that use bike as their main mode.

An increasing number of taxi trips generally leads to a decrease in shared bike usage. Especially cluster 2; the strict car users, and cluster 5; the shared modes users, are affected by this attribute. One effect that has now become statistically significant is unlimited access to BTM. People in cluster 1 would reduce their shared-bike use with an increase of BTM access. This was expected beforehand, however it does not apply to people in cluster 3 and 4. It thus seems that not everybody perceives these modes to be substitutes to each other.

6.5.1.6 Cluster differences own bike use

The only bundle attribute that significantly affects own bike use was found to be the inclusion of shared bikes in the general model. Hence the cluster differences with regards to this parameter will be discussed below.

Table 35 - Cluster differences mode use own bike

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-5,087	53,465	-5,13	17,322	-5,506	18,799			-0,335	0,005
	A little les	-3,344	34,853	-2,473	10,262	-2,925	12,246	-2,233	8,621	-0,122	0,001
	The same	1,673	11,394	2,528	10,659	3,301	14,545	2,472	10,095	5,545	1,229
	A little mo	2,705	23,455	5,18	17,57	4,957	15,712	5,264	17,941	5,803	1,341
Threshold	Much more										
	Unlimited	-0,194	0,145	0,249	0,129	0,614	0,631	0,677	1,038	2,234	0,281
	Free-offp	0,123	0,075	-0,181	0,088	0,635	0,67	0,261	0,156	0,533	0,029
	Weekend	0,162	0,128	0,006	0	1,001	1,719	0,114	0,029	1,69	1,008
Train	Always di	0	.	0	.	0	.	0	.	0	.
	Unlimited	-0,665	2,878	-0,501	0,926	-0,533	0,758	-0,291	0,245	1,85	1,524
BTM	Always di	0	.	0	.	0	.	0	.	0	.
	3 euro pe	0,078	0,049	-0,145	0,097	-0,083	0,021	-0,143	0,068	1,388	0,175
Shared car	4 euro pe	0	.	0	.	0	.	0	.	0	.
	Unlimited	**-1,162**	7,487	-0,198	0,137	-0,954	1,872	**-1,101**	4,543	-0,891	0,198
Shared bik	1 euro pe	0	.	0	.	0	.	0	.	0	.
	Taxi trips	0,043	0,241	0,068	0,331	-0,021	0,019	0,254	3,635	0,149	0,064
	Transferal	-0,008	0,001	0,539	1,284	0,243	0,18	-0,144	0,065	-0,663	0,377
Taxi	Not transf	0		0	.	0	.	0	.	0	.

Looking at the results for the different clusters, it can be seen that cluster 1 and 4 will decrease their own bike usage most as a result of having unlimited access to shared bikes. Cluster 1 and 4 already have a high level of experience with shared bikes, thus it is likely that the reduced bicycle trips are replaced with shared bikes. The strengths are however lower than the increase in shared bikes meaning that they would not only replace bicycle trips, but also other trips. The lowest effect is seen in cluster 2, however this is the group that uses their own bike least often.

6.5.1.7 Cluster differences taxi use

In the general model, only the number of included taxi trips was found to significantly effect taxi usage.

Table 36 - cluster differences mode use taxi

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-2,11	20,68	-4,96	17,42			-2,67	10,71	-4,22	1,10
	A little les	-1,69	15,42	-3,10	16,77	-2,61	15,47	-1,57	5,47	-3,76	0,88
	The same	1,33	11,11	1,05	2,76	1,50	7,64	2,61	13,72	-0,12	0,00
	A little mo	3,74	65,85	2,71	15,99	4,06	35,63	5,15	36,28	2,94	0,52
Threshold	Much more										
	Unlimited	0,51	1,67	0,16	0,09	0,11	0,04	0,62	1,01	-0,35	0,01
	Free-offp	0,12	0,12	-0,11	0,06	-0,43	0,60	-0,04	0,00	-0,17	0,01
	Weekend	0,30	0,72	-0,77	2,33	-0,18	0,12	0,01	0,00	-0,81	0,38
Train	Always di	0,00	.	0,00	.	0,00	.	0,00	.	0,00	.
	Unlimited	-0,46	2,35	-0,04	0,01	0,18	0,19	-0,37	0,53	-1,68	1,78
BTM	Always di	0,00	.	0,00	.	0,00	.	0,00	.	0,00	.
	3 euro pe	0,07	0,06	-0,12	0,10	-0,07	0,03	-0,05	0,01	-0,93	0,13
Shared car	4 euro pe	0,00	.	0,00	.	0,00	.	0,00	.	0,00	.
	Unlimited	0,18	0,36	0,11	0,07	0,22	0,25	0,19	0,17	1,15	0,48
Shared bik	1 euro pe	0,00	.	0,00	.	0,00	.	0,00	.	0,00	.
	Taxi trips	**0,42**	32,89	**0,21**	5,11	**0,21**	4,06	**0,53**	16,71	-0,10	0,04
	Transferal	0,17	0,39	-0,29	0,60	0,26	0,41	-0,12	0,07	0,33	0,14
Taxi	Not transf	0,00	.	0,00	.	0,00	.	0,00	.	0,00	.

Looking at the results of the different clusters, it can be seen that the highest increase in taxi use as a result of an increasing number of taxi trips included in the MaaS bundle is cluster 4. Cluster 1 would also increase their taxi use substantially. Cluster 2 and cluster 3 show about an equal increase in taxi use. Cluster 5 is too small to get reliable results.

6.5.2 Cluster differences total trip frequency

In the general results, the only significant effects that were found were unlimited access to both rail as BTM that led to an increase in total trip frequency.

Table 37 - Cluster specific results total trip frequency

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Much less	-3,075	27,765	-4,388	24,302	.	.	.	.		
	A little les	-2,361	23,117	-3,85	22,534	-3,946	11,952	.	.	-2,972	0,47
	The same	-1,154	7,486	-3,49	20,306	-2,108	9,326	-0,295	0,194	-2,699	0,388
	A little mo	1,512	12,611	1,599	5,764	2,415	12,462	4,395	29,286	1,202	0,077
Threshold	Much mor	4,896	75,964	4,18	23,428	5,863	35,606	.	.	3,725	0,71
	Unlimited	**1,652**	18,247	0,581	1,071	1,025	3,454	**1,72**	7,681	-1,118	0,105
	Free-offp	0,562	2,792	-1,342	5,117	1,163	4,144	0,896	1,911	-1,593	0,427
	Weekend	0,427	1,627	-0,638	1,305	0,469	0,746	0,441	0,486	-0,303	0,051
Train	Always di	0	.	0	.	0	.	0	.	0	.
	Unlimited	0,474	2,866	0,117	0,062	0,675	2,501	1,093	3,497	0,714	0,321
BTM	Always di	0	.	0	.	0	.	0	.	0	.
	3 euro pe	0,152	0,351	-0,135	0,107	0,555	1,921	0,442	0,803	-0,8	0,089
Shared car	4 euro pe	0	.	0	.	0	.	0	.	0	.
	Unlimited	0,041	0,019	0,716	2,36	-0,221	0,248	0,026	0,003	0,157	0,009
hared bik	1 euro pe	0	.	0	.	0	.	0	.	0	.
	Taxi trips	0,04	0,369	-0,025	0,058	0,041	0,164	0,236	3,996	-0,197	0,144
	Transferal	-0,077	0,09	-0,124	0,085	0,006	0	0,348	0,45	0,91	0,926
Taxi	Not transf	0	.	0	.	0	.	0	.	0	.

In the cluster-specific results, differences can be seen between the clusters. As it can be seen that the largest effect of unlimited rail on increasing total trip frequency can be observed in cluster 4. This same cluster also shows significant increase in total trip frequency with a growing number of taxi trips. This thus indicates that the taxi trips would not replace other trips, but rather lead to additional trips being made. Furthermore, the highest increase in the number of trips as a result of unlimited access to BTM is observed in this cluster. It thus seems that people in cluster 4 have a large latent desire for travelling more often.

Cluster 1 also shows a large increase in trip frequency as a result of unlimited access to rail. However, the other rail bundle attributes lead to a much smaller increase in total trip frequency. The inclusion of taxi trips barely have any influence in this cluster, even though they were most likely to increase their taxi use with an increasing number of taxi trips in their bundle. This thus indicates that these taxi trips would replace trips by other modes, rather than induce total trip frequency.

Much smaller and even negative effects are found in cluster 2. The strict car users would decrease total trip frequency if they received free off-peak rail travel, or weekend-free + off-peak discount. This could mean that they would work more often from home for example.

People in cluster 3 would significantly increase their travel as a result of the inclusion of rail attributes. BTM also has quite a high effect, but taxi trips are barely influencing total trip frequency.

6.5.3 Cluster differences peak-hour avoidance

Below the cluster differences with regards to peak-hour avoidance are shown. The rail attributes other than unlimited travel were found to significantly influence peak-hour avoidance in the general model. The differences between the clusters on these parameter estimates will thus be discussed.

Table 38 - Peak-hour avoidance cluster differences

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
		Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
	Intercept	-1,891	13,024	-0,846	2,029	-1,942	7,583	-1,136	14,678	-1,136	14,678
	Unlimited	**2,454**	25,149	0,972	2,995	0,595	0,833	0,283	1,645	0,283	1,645
	Free off-p	**2,252**	21,803	0,488	0,758	0,078	0,015	0,602	7,629	0,602	7,629
	Weekend	**1,46**	8,971	0,251	0,195	0,103	0,028	-0,955	11,566	-0,955	11,566
Train	Always di	0	.	0	.	0	.	0	.	0	.
	Unlimited	0,066	0,049	-0,316	0,594	0,269	0,361	0,009	0,002	0,009	0,002
BTM	Always di	0	.	0	.	0	.	0	.	0	.
	€3/hour +	-0,435	2,203	-0,655	2,728	0,385	0,762	0,187	1,039	0,187	1,039
Shared car	€4/hour +	0	.	0	.	0	.				
	Unlimited	0,125	0,125	0,142	0,114	0,337	0,48	0,016	0,007	0,016	0,007
Shared bik	€1 per rid	0	.	0	.	0	.				
	Taxi trips	0,038	0,242	0,013	0,017	-0,032	0,085	-0,012	0,061	-0,012	0,061
	Transferal	0,494	0,459	-0,49	1,595	0,225	0,28	-0,164	0,888	-0,164	0,888
Taxi	Not transf	0	.	0	.	0	.	0	0	0	0

Clusters show differences with regards to peak hour avoidance. The largest effects are observed in cluster 1. It thus seems that the people in this cluster are most willing to travel more outside of peak-hours. For cluster 4 and 5 no results could be obtained, therefore the results of the general model have been used here.

6.5.4 Cluster differences car-shedding

Since it was already impossible to estimate regression models with regards to car-shedding on all data, unfortunately no results could be obtained for cluster differences either.

6.6 ADOPTION OF MAAS BUNDLES

This section aims to answer sub question 3: "*What are the effects of bundle elements on the willingness to adopt MaaS for the different identified travelers in the Netherlands?*": In order to answer this question, first the effects of bundle elements on adoption are analyzed. Since respondents were asked if they would adopt each shown bundle, binary logistic regression could be used to study the effects of the predictor variables (bundle attributes) on the outcome (decision to adopt). The categorical variables are dummy-coded, with the lowest level as the reference category.

Table 39 - Parameter estimates stated choice model

		Estimate	**Wald**
Intercept		**-1,137**	10,782
Train	Unlimited travel	**1,381**	21,848
	Free-off-peak + weekend	**0,793**	6,991
	Weekend-free + off-peak discount	0,196	0,427
	Always discount	0	.
BTM	Unlimited travel	0,12	0,27
	Always discount	0	.
Shared car	3 euro per hour + 0,24 cents per kilometer	**0,425**	3,985
	4 euro per hour + 0,29 cents per kilometer	0	.
Shared bike	Unlimited trips up to 40 min	-0,12	0,277
	1 euro per trip up to 40 minutes	0	.
Taxi	Taxi trips	0,007	0,021
	Transferable	0,136	0,382
	Not transferable	0	.
Price		**-0,005**	46,759

In **Error! Reference source not found.** the results of the stated choice model are displayed. As can be seen, there is a base disutility associated with MaaS bundles, as shown by the negative intercept estimate. This is the disutility people encounter from receiving the bundle, when all attributes are zero, compared to not choosing for MaaS. It thus means that a 'minimum bundle' consisting of always discount on rail and BTM, the more expensive tariffs for shared bike and shared cars, and 0 taxi trips, costing nothing would be valued less as opposed to maintaining the current situation.

The train bundle attribute is positive and significant at the levels free off-peak + weekend and unlimited travel. It thus becomes clear that the willingness to adopt a MaaS bundle increases with unlimited access to train. Higher levels of shared car also significantly influence the willingness to adopt MaaS in a positive way. It must be noted however that the effect for unlimited train access is much stronger i.e. people prefer the inclusion of rail more than shared cars in their bundles.

An increasing price significantly reduces the willingness to adopt MaaS, which is as expected. For every euro increase in price, utility decreases with 0,005. Interesting to note is that the inclusion of BTM, shared bikes and taxi's do not significantly contribute to the willingness to adopt MaaS. The sign of unlimited shared bikes is even negative, which could indicate people do not prefer to have them in their bundles at all. Taxi trips are slightly positive, which increases utility especially when they can be taken to the next month. In the figures below, the utility contributions are visualized for the attributes.

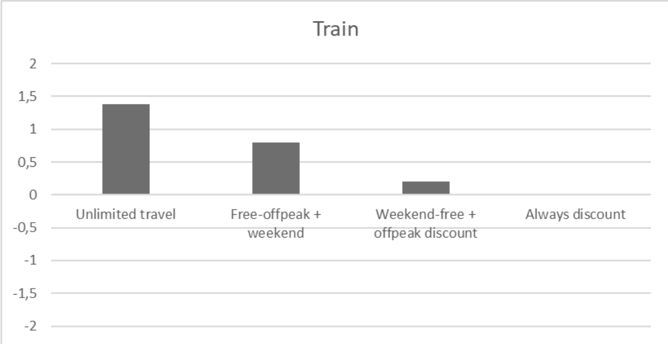

Figure 13 - Utility contribution train

Figure 14 - Utility contribution BTM

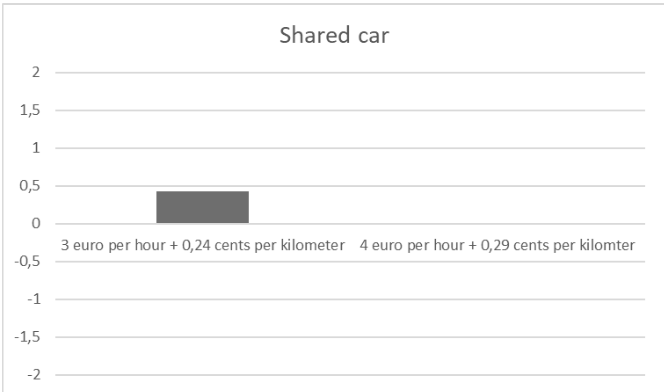

Figure 15 - Utility contribution shared car

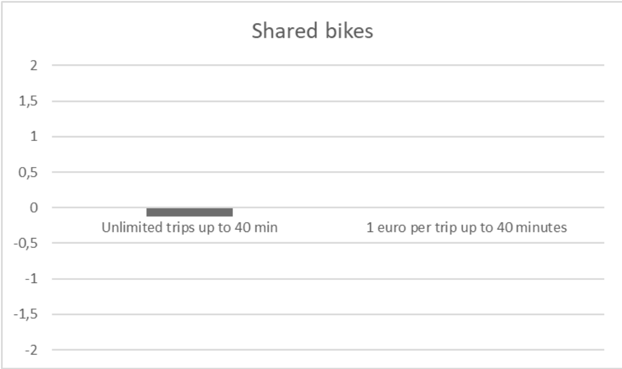

Figure 16 - Utility contribution shared bikes

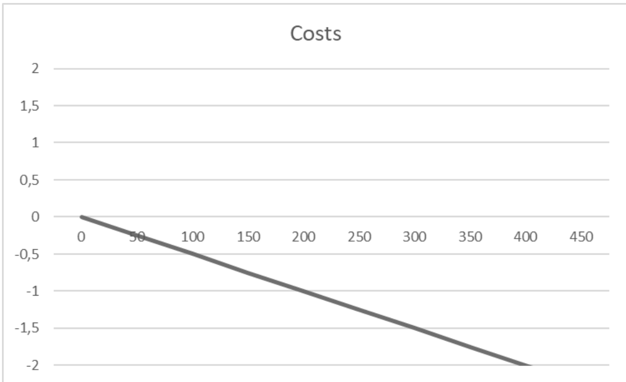

Figure 17 - Utility contribution cost attribute

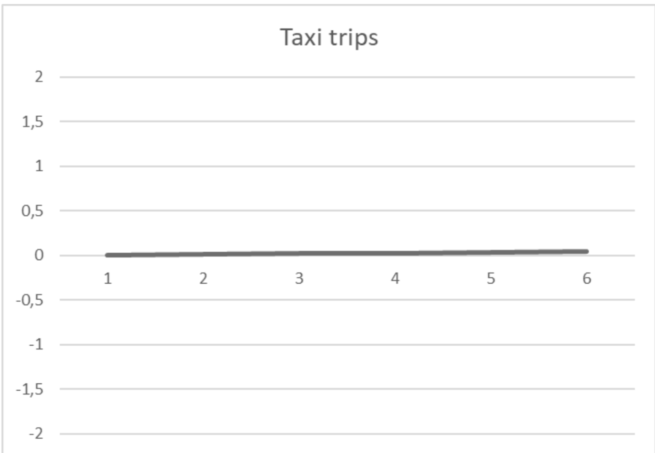

Figure 18 - Utility contribution taxi attribute

6.7 CLUSTER DIFFERENCES ADOPTION

Table 40 - Cluster differences willingness to adopt

		Cluster 1 - PT + bike		Cluster 2 - Strict car		Cluster 3- Bike + car		Cluster 4 - PT + car		Cluster 5 - Shared	
	Attributes	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald	Estimate	Wald
Intercept		-0,309	0,372	-2,84	6,737	-0,691	1,06	-2,264	3,336	-	-
Price		**-0,008**	35,228	-0,001	0,184	**-0,007**	11,848	**-0,005**	4,942	-	-
	Unlimited	**2,207**	15,617	1,073	2,305	0,981	1,551	**1,526**	4,083	-	-
	Free-offp	1,421	6,53	1,18	3,135	0,345	0,163	1,265	2,273	-	-
	Weekend	0,482	0,831	0,493	0,496	0,555	0,735	-1,272	0,959	-	-
Train	Always di	0	.	0	.	0	.	0	.	-	-
	Unlimited	-0,114	0,083	0,823	2,439	-0,668	1,446	0,775	1,121	-	-
BTM	Always di	0	.	0	.	0	.	0	.	-	-
	3 euro pe	0,346	0,836	0,543	1,193	0,859	2,743	0,471	0,427	-	-
Shared car	4 euro pe	0	.	0	.	0	.	0	.	-	-
	Unlimited	-0,625	1,966	-0,098	0,037	-0,81	1,383	0,372	0,425	-	-
Shared bik	1 euro pe	0	.	0	.	0	.	0	.	-	-
	Taxi trips	0,047	0,29	0,026	0,044	0,102	0,479	0,027	0,034	-	-
	Transferal	0,32	0,745	-0,136	0,071	0,418	0,589	0,397	0,324	-	-
Taxi	Not transf	0	.	0	.	0	.	0	.	-	-

In Table 40, the stated choice models for the different clusters are displayed. Cluster 5 was unfortunately too small to obtain any reliable results.

The intercepts of the clusters indicate the different base disutilities associated with the minimum MaaS bundle (i.e. all attribute levels 0) between the clusters. Cluster 1, the PT + bike users, have the lowest base disutility. This means that initially these could be the most likely adopters of MaaS. Their price sensitivity is however highest compared to the other clusters, meaning that an increasing price quickly reduces the likeliness to adopt a bundle. Especially the inclusion of unlimited access to train is important for this cluster. The inclusion of shared cars is least important to this cluster, which could be explained by the fact that the people in this cluster have the lowest share of driving license holders. The inclusion of BTM is also negative, perhaps because people in this group rather use their own bike. Interesting is that this cluster does not positively value the inclusion of shared bikes, even though they are using bike often.

Cluster 2, the strict car users have the highest base disutility associated to them, and thus initially seem to be the least likely adopters of MaaS. However price sensitivity of this group is relatively low, and the inclusion of attributes have positive influence on the willingness to adopt MaaS. Train is most important for this cluster as well, but less so than for the public transport users. This cluster attaches most value to the inclusion of shared cars compared to the other clusters. This group also strongly values the inclusion of BTM.

Cluster 4, the PT+car users are next in line when it comes to a high initial disutility. However, all bundle attributes positively influence the decision to adopt MaaS. Their price sensitivity is average, and especially access to train is positively influencing willingness to adopt MaaS. Weekend free + off-peak discount is however not enough for them, and therefore negatively influences willingness to adopt MaaS. Interesting to note is that they are the only group positively valuing the inclusion of shared bikes.

Cluster 3, the bike + car users, are quite price sensitive. The inclusion of rail is least important to them compared to the other clusters. They place most value on the inclusion of taxi compared to the other clusters. Interesting is that shared bikes, shared cars and BTM are all negatively influencing decision to adopt MaaS.

7 MODEL APPLICATION

This chapter will answer the final sub question: *"How can bundles be constructed in order to align their impacts with public policy goals,* and what are the corresponding effects of these bundle configurations?*"* Various scenarios for MaaS bundle configurations have been drawn up that each support different policy goals. By applying the model, response distributions can be obtained on the dependent variables. In the case of the ordinal dependent variables these response distributions are also multiplied by the factor that was introduced to the respondents in the introduction. These factors are: (-50% – a lot less, -25% – a little less, 100% – the same; +25% – a little more; to +50% – a lot more). The sum of these distributions then gives an indication of the total average effects on travel behavior change in the population. By doing so, the effects of different bundle designs on travel behavior change, and adoption rates, can be estimated so that optimal bundle configurations that support specific policy goals can be determined.

In the general model applications (section 7.1), current travel behavior is however not yet taken into account. In Section 7.2 the cluster specific models are therefore applied and the estimated effects are multiplied with current known travel behavior of each cluster in order to obtain an estimate of absolute changes in travel behavior in the population given different bundle designs. Based on these estimates, recommendations for the design of MaaS bundles, knowing absolute effects, can be provided, which are especially useful for policy makers and MaaS companies. It provide them insight into how the design of MaaS bundles influences adoption, travel behavior change, and subsequently how they contribute to public policy goals.

7.1 BUNDLE CONFIGURATIONS

The models have been applied to the following bundle configurations:

1. Minimum package (all attribute levels 0)
2. Maximum package
3. Maximize decrease in car-usage
4. Maximize increase in shared car usage
5. Maximize increase in shared bike use
6. Maximize peak-hour avoidance

7.1.1 Scenario 1: Minimum bundle

The first scenario can be considered the base scenario. In this scenario, all bundle attributes are set at thei minimal value. This means the following attribute levels are included in the bundle:

- Rail: Always discount
- BTM: Always discount
- Shared car: €4 per hour + €0,29 per km
- Shared bike: €1 per ride up to 40 min
- 0 taxi trips
- Non transferable

7.1.1.1 *Impacts on travel behavior*

In the following figure, the changes in mode use are dispayed, given the minimal MaaS bundle.

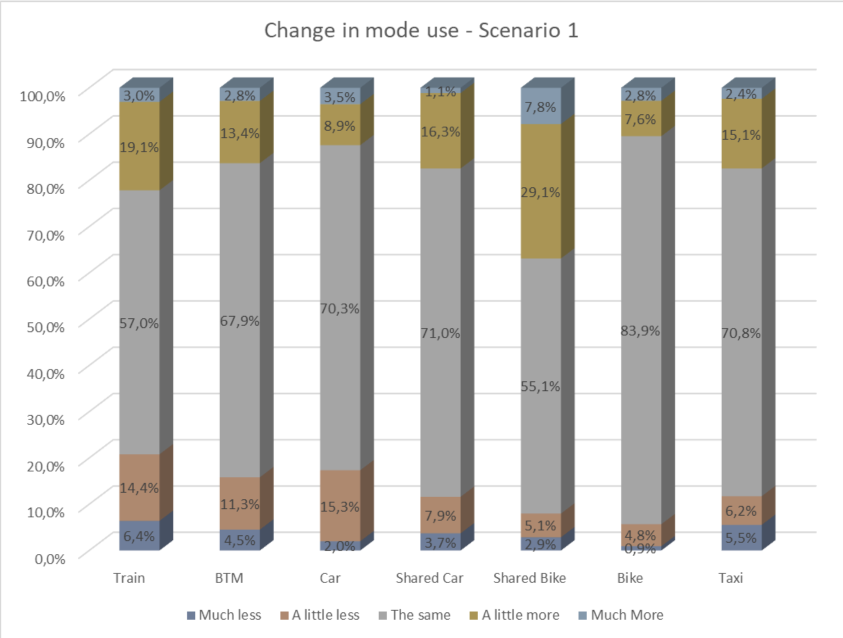

Figure 19 - Change in mode use: Scenario 1

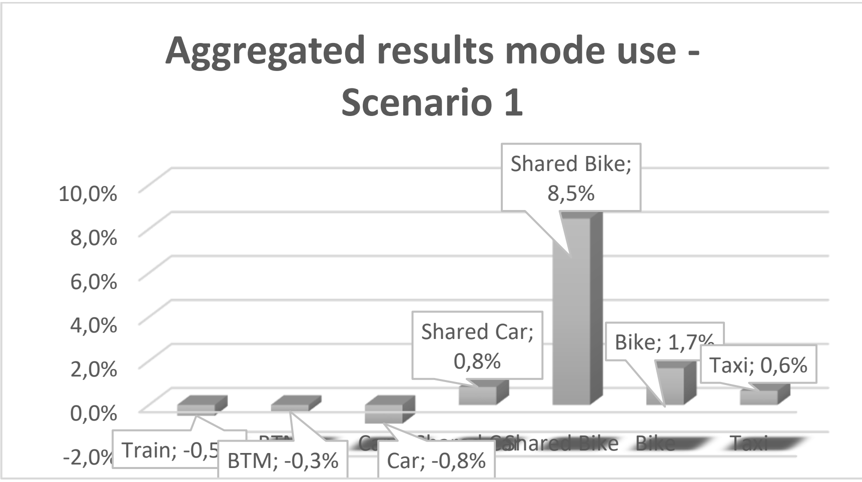

Figure 20 - Aggregated effects on mode use : Scenario 1

Table 41 - Change in total trip frequency: Scenario 1

	Total trip frequency
Much less	2,4%
A little less	8,5%
The same	73,2%
A little more	12,8%
Much More	0,8%

Total	97,6%
Difference	**-2,4%**

Table 42 - Peak hour avoidance : Scenario 1

Peak-hour avoidance	
yes	24%
no	76%

In Figure 19 the effects on mode use of the reference bundle are shown. As can be seen, in scenario 1, only shared-bike use would be increased substantially by 8,5%. A slight increase of 1,7% in bike-use is also observed. All other effects are less than a 1% change in total. Interesting to note is that even with zero taxi trips included, taxi use would still slightly increase with a MaaS bundle, perhaps because the integration of taxi on the MaaS platform makes it easier to contemplate taxi use.

In Table 41, the effects on total trip frequency are shown. The total trip freuqency would be reduced by 2,4%. This means that when receiving this MaaS bundle, on average the amount of trips people make would go down by a little.

Furthermore, as can be seen in

Table 42, 24% of the people would travel more outside of peak-hours. This shows the potential effect of offering discounts outside of peak-hours.

7.1.1.2 Willingness to adopt

Table 43 - Willingness to adopt bundle: Scenario 1

Stated choice	**€50**	**€125**	**€200**	**€275**	**€350**	**€425**
yes	20%	14,7%	10,6%	7,5%	5,3%	3,7%
no	80%	85.3%	89,4%	92,5%	94,7%	96,3%

However, only 20% of the people would adopt this bundle at the price of 50 euro per month. This means that in order to get an estimate on the potential absolute effects, only a share of 20% would change its behavior in the estimated direction. The other 80% would maintain their current behavior.

7.1.2 Scenario 2: Maximum bundle

Scenario 2 is the opposite of the reference scenario, in the sense that all attributes are set at their maximum value. This means the attribute levels are set to:

- Rail: Unlimited travel
- BTM: Unlimited travel
- Shared car: €3 per hour + €0,24 per km.
- Shared bike: Unlimited rideds up to 40 min
- 6 free taxi trips up to 5km, transferable to the next month

7.1.2.1 Imapcts on travel behavior

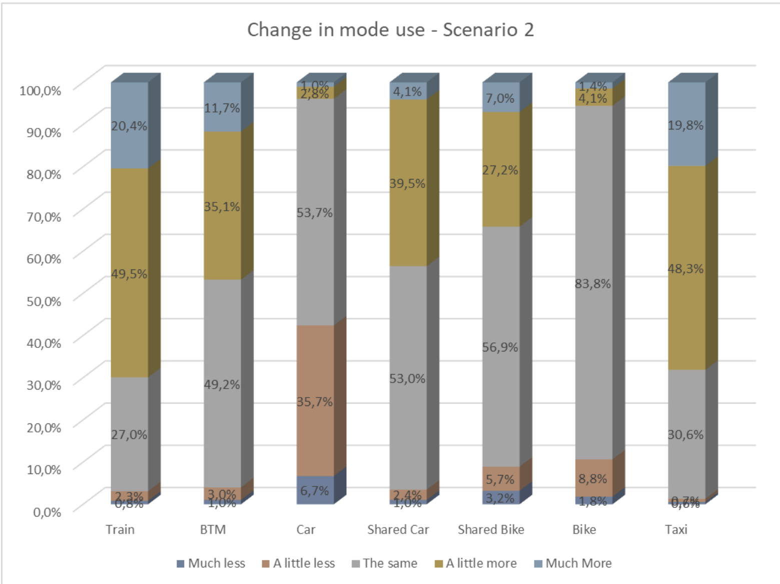

Figure 21 - Change in mode use: Scenario 2

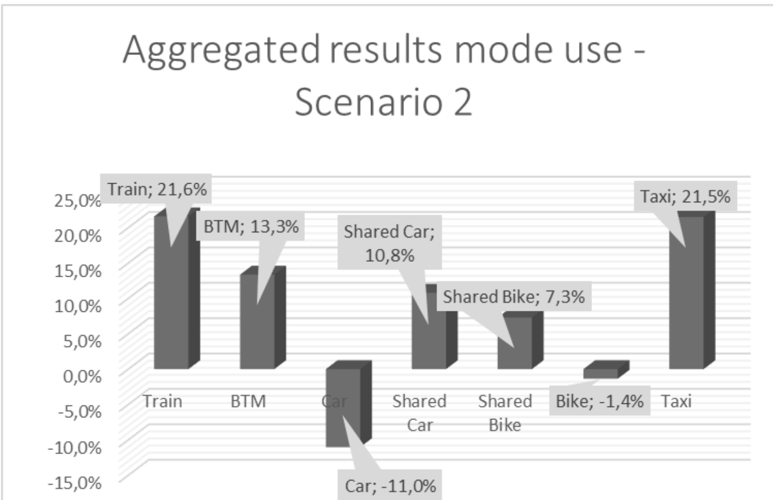

Figure 22 - Aggregate effects change in mode use: Scenario 2

Table 44 - Peak hour avoidance: Scenario 2

peak-hour avoidance	
yes	29,4%
no	70,6%

Table 45 - Total trip frequency: Scenario 2

	Total trip frequency
Much less	0,2%
A little less	11,7%
The same	73,2%
A little more	12,8%
Much More	0,8%
Total	98,7%
Difference	-1,3%

In the figures and tables above, the effects of scenario 2 are shown. As can be seen, all modes are used more often, except for car and bike. People would decrease their car use on average with 11%, which is quite substantial. According to Van Wee (2018) “if there would be 10% less cars on the roads, congestion would be reduced by 20-50%” (Trouw, 2018). Train use would increase substantially with a total of 21,6%. If 29,4% of all these trips would be made off-peak, the increase in train travel during peak-hours would however still be substantial. Increase in BTM use is with 13,6% a little more moderate. Furthermore, also shared modes would be used more often. Taxi use would however also increase substantially, with a total of 20,6%.

Nonetheless, the total effects on trip frequency would be reduced by 1,3%. This result suggests that the increased use of modes as shown in Figure 22 would be due to an increase in multi-modal travel, and the total effects are actually more pointing in the direction towards less travel.

7.1.2.2 Willingness to adopt

Table 46 - Stated choice: Maximum bundle at different bundle prices

	€425	€350	€275	€200	€125	€50
yes	21,8%	28,8%	37,1%	46,2%	55,5%	64,5%
no	78,2%	71,2%	62,9%	53,8%	44,5%	35,5%

Above, the adoption rates, and corresponding absolute effects at different prices are shown. As can be seen, at a price of €425 per month, adoption would be 22%. However, if price could be reduced (perhaps with the support of employers, or government subsidy) adoption rates to almost 65% at €50. Absolute effects in travel behavior change would therefore also increase substantially.

7.1.3 Scenario 3: Bundle to minimize car use

In the third scenario, minimizing car use is set as an objective. With the use of Excel's add-in Solver, this target was set while the bundle attributes were allowed to vary. This resulted in the following bundle attributes:

- Rail: Unlimited travel
- BTM: Unlimited travel
- Shared car: €3 per hour + €0,24 per km.
- Shared bike: Unlimited rideds up to 40 min
- 6 free taxi trips up to 5km, not transferable to the next month

As can be seen, the only difference with regards to the maximum bundle is that taxitrips cannot be taken to the next month. The results on mode change are shown below. They are slightly different compared to the maxmium

7.1.3.1 Impacts on travel behavior

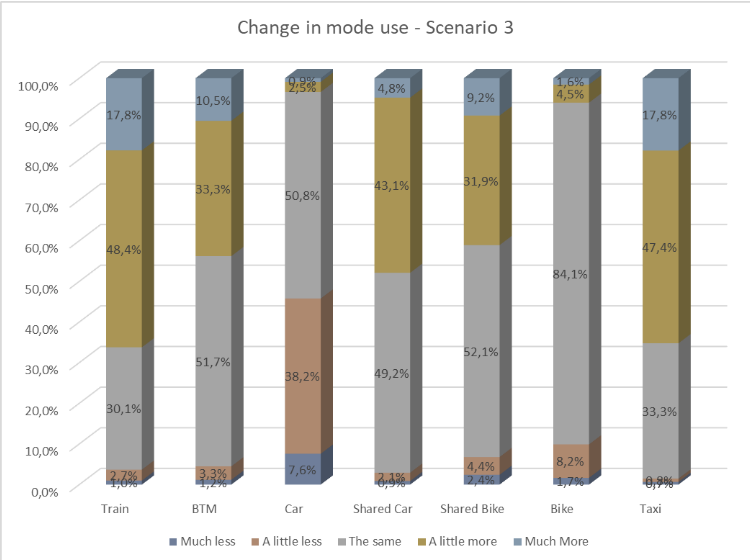

Figure 23 - Change in mode use: Scenario 3

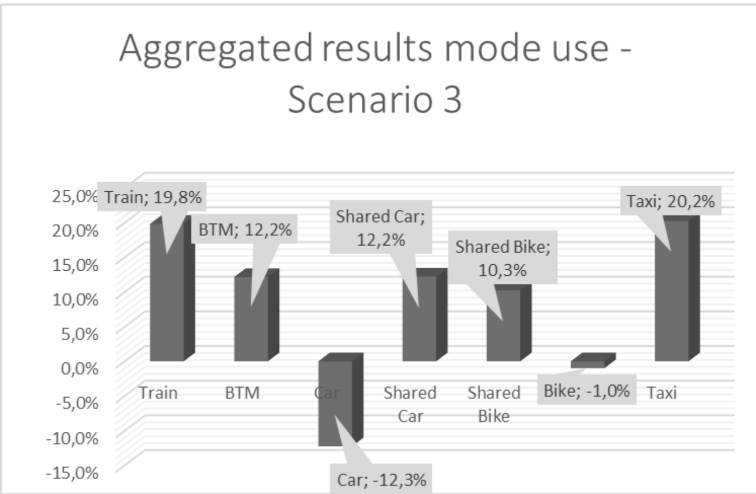

Figure 24 - Aggregated effects on mode change: Scenario 3

Table 47 - Total trip frequency: Scenario 3

	Total trip frequency
Much less	0,2%
A little less	11,7%
The same	73,2%
A little more	12,8%
Much More	0,8%
Total	98,7%
Difference	-1,3%

Table 48 - Peak-hour avoidance: Scenario 3

Peak-hour avoidance	
yes	29,4%
no	70,6%

Due to this slight change, effects on travel behavior are also slightly different. Car use would be reduced with 1,3 percentage point compared to scenario 2. However when adoption was taken into account as well, transferability of credits was preferred hence the optimal bundle to reduce car use becomes the same as scenario 2.

7.1.4 Scenario 4: Bundle to maximize shared car use

In scenario 4, first the objective was set to maximize shared-car use. This resulted in the same bundle as in scenario 2, hence also the same effects on travel behavior. It thus has to be noted that scenario 2 has so far been optimal for al previously set objectives.

7.1.5 Scenario 5: Bundle to maximize shared bike use

Then, shared bike use was set as the objective to maximize. This resulted in the following bundle configuration:

- Train: Unlimited
- BTM: Always discount
- Shared car: 4 euro per hour + 0,29 cent per km
- Shared bike: Unlimited rides up to 40 min
- Taxi: 0 free trips, not transferable

As can be seen, in order to reach the objective of maximizing shared bike usage, the inclusion of BTM should thus not be set to unlimited access, otherwise shared-bike use would be decreased. Moreover, the number of taxi trips should be set to 0 for the same reason.

7.1.5.1 *Impacts on travel behavior*

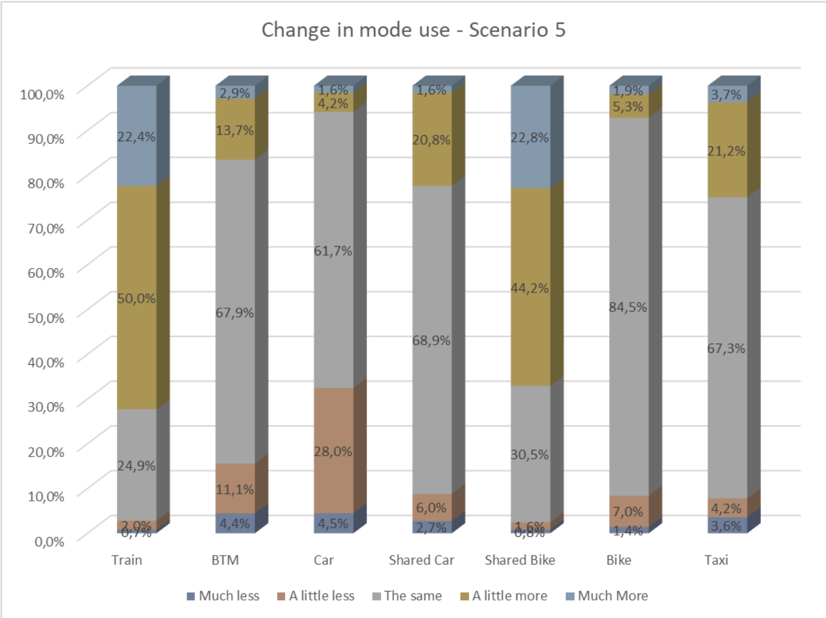

Figure 25 - Change in mode use: Scenario 5

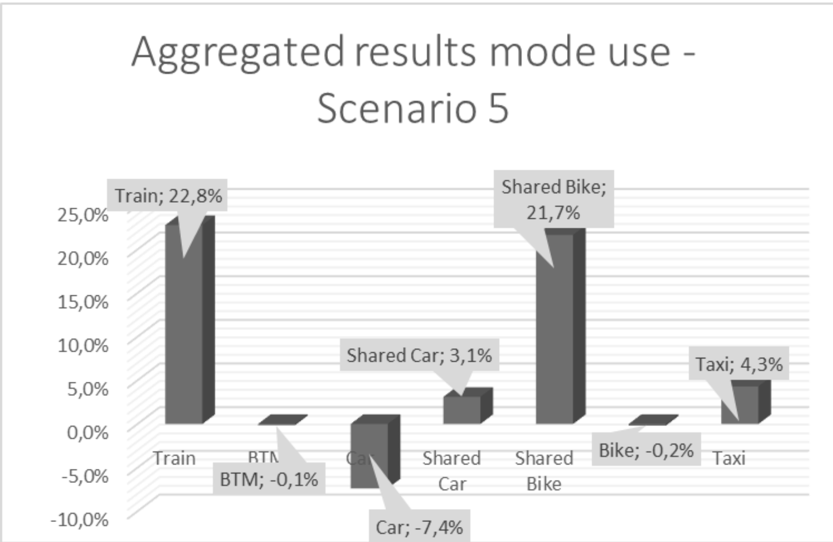

Figure 26 - Aggregated effects mode use: Scenario 5

Table 49 - Peak-hour avoidance: Scenario 5

Peak-hour avoidance	
yes	34,3%
no	65,7%

Above, the results effects on travel behavior change are shown for scenario 5. As can be seen, with this bundle configuration, shared bike use increases with 21,7%. The effects on increase in train use are similar to the other bundles, but car use decreases with a smaller percentage. Also shared-car use does not increase by a lot.

7.1.5.2 *Impacts on willingness to adopt*

Table 50 - Stated choice: Scenario 5

stated choice	€425	€350	€275	€200	€125	€50
yes	17,1%	23,1%	30,4%	38,9%	48,1%	57,4%
no	82,9%	76,9%	69,6%	61,1%	51,9%	42,6%

In Table 50 the adoption rates at different prices are shown. At a price of 425 euro, 17,1% of the population would adopt the bundle. This increases to a max of 57% at a price of 50 euro. When adding up bundle attributes, 350 euro could be considered a reasonable price for the included attributes. In this scenario, adoption would be 23,1%.

7.1.6 Scenario 6: Bundle to maximize off-peak travelling

In scenario 5, the objective was set at maximizing the amount of off-peak travelling. This resulted in the following bundle configuration:

- Train: Free off-peak + weekend
- BTM: Unlimited travel
- Shared car: 3 euro per hour + 0,24 per km
- Shared bike: unlimited trips up to 40 min
- 0 taxi trips, not transferable

7.1.6.1 *Impacts on travel behavior*

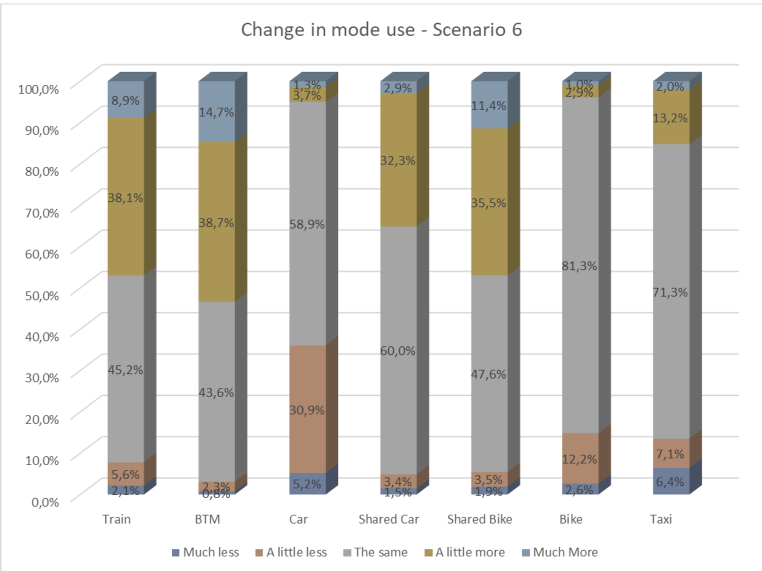

Figure 27 - Change in mode use: Scenario 6

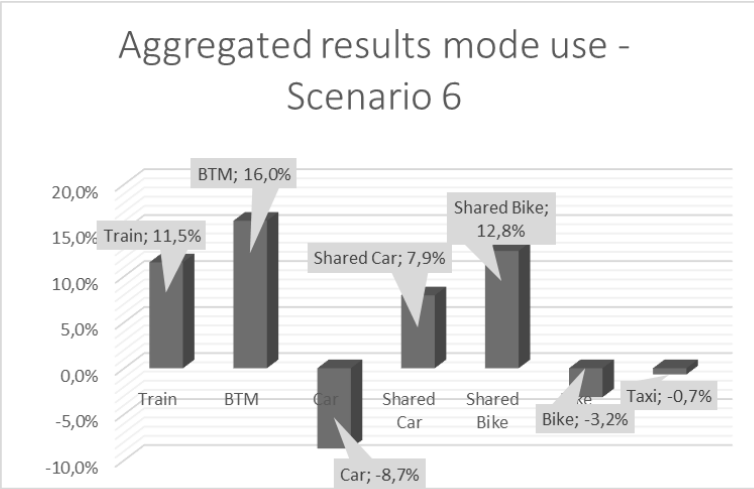

Figure 28 - Aggregate effects mode use: Scenario 6

Table 51 - Peak hour avoidance: Scenario 6

peak-hour avoidance	
yes	42,0%
no	58,0%

Table 52 - Total trip frequency: Scenario 6

	total trip frequency
Much less	0,7%
A little less	11,0%
The same	73,2%
A little more	12,8%
Much More	0,8%
Total	98,4%
Difference	-1,6%

When maximizing off-peak travelling is set as the objective it can be seen that users would increase their off-peak travelling with 42%. BTM use would increase with 16% whereas train 'only' increases with 11%. It can be expected however that much of this train use would be increased off-peak. Car use would be decreased with 8,7%, and shared cars increase by 7,9%. Shared bike use would still increase substantially, and own bike use a little.

7.1.6.2 Impacts on willingness to adopt

Table 53 - Stated choice: Scenario 6

stated choice	**€425**	**€350**	**€275**	**€200**	**€125**	**€50**
yes	11,5%	15,9%	21,5%	28,5%	36,7%	45,8%
no	88,5%	84,1%	78,5%	71,5%	63,3%	54,2%

In Table 53, the adoption rates at different prices are shown. These range from 11,5% at 425 euro, to 45,8% at 50 euro. When adding up the attribute costs, a reasonable price for this bundle could be 275 euro. Adoption would then be 21,5%.

7.2 Model application – clusters

Now that the models based on the entire dataset have been applied, insight can be gained into the effects and preferences of the different clusters. This can be especially helpful because by taking into consideration the current travel behavior of potential users, absolute effects can be estimated. By knowing the characteristics of the people in each cluster, specific policy can be designed in order to align the impacts with policy objectives.

Since the current travel behavior is known of each cluster, changes in behavior can be quantified. Only travel behavior regarding mode use is known, therefore in this section only the differences in mode use will be quantified. Before this can be done, some steps need to be taken.

1. The ordinal scale of mode use has to be transformed into an interval scale with the same units. This is done by multiplying the average of each ordinal answer category so that a number of days/year is obtained. For instance, for the answer category 3-4 days per week the middle value (3,5) is multiplied by 52 such that an average value of 182 days/year is obtained. This is done for each value.
2. The obtained values are then multiplied with the answer distributions of the current travel behavior of each cluster. Thereby the total relative travel behavior of each cluster for each mode can be calculated.
3. The models are then estimated for different scenarios to obtain the average travel behavior change of each cluster for these scenarios
4. The outcomes of travel behavior change (a percentual increase/decrease) is then multiplied by the current travel behavior as calculated in step 1.
5. The stated choice model is multiplied with the stated adaptation model so that the non-adopters remain their current behavior, and the adopters change their behavior. (Since no stated choice model was obtained for cluster 5, the general model was applied for this cluster)
6. The absolute change in travel behavior change are then calculated, and compared with the current travel behavior in order to obtain absolute percentual increase in travel behavior change

7.2.1 Minimum bundle

Below, the aggregated changes in travel behavior by the different clusters are shown. Results for cluster 5 have to be interpreted with caution, due to its small size and therefore unreliably estimated parameters.

Table 54 - Aggregate changes in travel behavior: Scenario 1

Clusters	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
1: PT + bike	-0,1%	-0,6%	-0,3%	2,4%	14,2%	4,5%	-0,8%
2: Car mostly	4,4%	1,5%	-2,8%	2,0%	11,7%	-0,1%	6,8%
3: Bike + car	3,8%	6,4%	-6,2%	3,9%	2,3%	-0,3%	3,3%
4: PT + car	-9,6%	6,4%	3,1%	-4,7%	1,5%	-0,3%	-4,1%
5: Shared	5,4%	-32,4%	-11,2%	-50,0%	38,7%	-22,0%	13,5%

Potential absolute changes	-3%	1%	-3%	-33%	15%	1%	4%

When looking at the impacts of the rference scenario on mode use of the different clusters, it can be seen that the if people in cluster 1 would have this bundle, they would increase their shared bike, and bike use mostly. Impacts on public transport use are rater small, but slightly negative. The car-mostly group would increase train, taxi and shared bike use mostly. Car use would decrease by a little, but since they use their car most often compared to the other groups, impacts could already be quite large. Cluster 3, would decreased their car use to the largest extent compared to the other clusters. This cluster is already using car quite often, so this result is promising. Cluster 4, would decrease their train use by a lot, and even increase their car use. As can be seen, this bundle thus does not lead to more sustainable behavior for all people. The absolute total effects that could potentially be reached if all users would adopt this bundle is shown in the bottom row in the table. It must be noted however that the shared car use however gives a distorted picture due to the influence of cluster 5.

Table 55 - Adoption rates: Scenario 1

€50	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
yes	**33,0%**	4,8%	26,1%	5,3%	20,0%
no	67,0%	95,2%	73,9%	94,7%	80,0%

Table 56 - Absolute changes in travel behavior population: Scenario 1

	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
with cluster 5	-0,1%	-0,1%	-0,4%	-6,6%	3,9%	0,4%	0,6%
without cluster 5	-0,1%	0,1%	-0,3%	0,5%	3,1%	0,6%	0,0%

In Table 55 the adoption rates are shown at a price of €50. As can be seen, the highest adoption rates can be expected from cluster 1, the PT + bike users. Cluster 3, the bike + car users would be second most likely group to adopt this bundle. Cluster 2 and 4 are least likely to adopt the bundle.

In Table 56 the absolute impacts on travel behavior of the population are calculated, taking into account the adoption levels at a price of €50, and the current travel behavior of the clusters. As can be seen, with this bundle, car use would only decrease with 0,4%. This limited effects is due to the fact that the bundle is not very popular among car users. The decrease in shared car use can be explained by the fact that cluster 5 currently uses shared car most often, but would decrease car-use in the case of this bundle quite substantially. Since for this cluster no stated choice model could be estimated, the general stated choice model was maintained for this cluster. This could however lead to unreliable adoption levels, and therefore the absolute changes have been calculated without the impacts of cluster 5. As can be seen, the absolute effects on shared car are a lot smaller. The other changes in travel behavior are in similar regions. As can be seen, impacts on car use, PT use, bike and taxi use are all very small. Shared bike use would however still increase significantly.

7.2.2 Maximum bundle

Below the results of change in mode use in the case of the maximum bundle are shown.

Table 57 - Change in mode use: Scenario 2

clusters	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
1: PT + bike	27,6%	12,0%	-12,6%	13,9%	11,4%	-3,7%	28,7%
2: Car mostly	20,1%	14,6%	-14,9%	9,6%	9,1%	1,2%	16,6%
3: Bike + car	22,9%	13,2%	-21,9%	10,2%	5,9%	-2,5%	17,8%
4: PT + car	25,0%	13,2%	1,6%	7,1%	4,6%	1,8%	20,8%
5: Shared	-12,0%	16,4%	-1,8%	12,0%	-41,4%	14,6%	-3,5%
Potential absolute changes	32%	13%	-14%	12%	1%	-1%	17%

As can be seen, with the largest bundle configuration, (potential) travel behavior changes would be much larger. The largest increases in mode use if people would have this bundle can be expected for train use. Almost everyone would use a lot more. Current public transport users: cluster 1 and 4, would increase it most strongly. The increase in BTM use is about equal among all clusters, but a little lower than train use. Car use would be reduced most strongly by people in cluster 3. These people currently use car in addition to their main mode: bike. Cluster 2 would also decrease their car use by a lot, which is positive given the fact that they have make use of the car most often. Shared car use would be increased quite substantially by all clusters. Shared bike use would be increased mostly by people in cluster 1 and 2, and taxi would be increased a lot by all clusters. As can be seen, in comparison to the reference bundle, shared car use would not increase as much, due to the inclusion of unlimited BTM and 6 free taxi trips per month.

Table 58 - Adoption rates: Scenario 2

€425	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
yes	21,5%	14,8%	1,8%	**26,0%**	21,8%
no	78,5%	85,2%	98,2%	74,0%	78,2%

Table 59 - Absolute change in mode use population: Scenario 2

	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
with cluster 5	5,5%	2,7%	-1,6%	2,6%	0,1%	-0,1%	3,3%
without cluster 5	5,8%	2,6%	-1,6%	2,6%	2,0%	-0,3%	4,5%

In Table 58 the adoption rates for the maximum MaaS bundle at a price of 425 euro are shown. Cluster 4, current PT + car users would be most likely to adopt this bundle. They would however not reduce their car use with this bundle, so there are no positive sustainability effects associated with their adoption. Cluster 3 is least likely, with only 1,8% of people interested. This is unfortunate, since they were most likely to reduce their car use with this bundle. Adoption levels of 14,8% by cluster 2 can be expected. Even though this is quite low, this means effect on car use would be quite large, as they are the cluster that uses car most often.

In Table 59 the absolute results are shown, both including and excluding results of cluster 5. As can be seen, taking into account adoption rates at 425 euro, the max MaaS bundle would increase train use substantially. This is due to the fact that the bundle is quite popular among current PT users. Shared car and BTM use would also increase, but to a lesser extent. The absolute impacts on car use are with 1,6% not very large, but are the highest of all bundle configurations. This is due to the fact that current car users are less likely to adopt the bundle, making the absolute impact on car use not that big. Besides, it has to be noted that taxi use and shared-car use would also increase, which are also car-based, and therefore the total effect of decreasing car use would even be smaller.

7.2.3 Scenario 3 – Maximize shared bike use

Below the results are shown when the bundle attributes are aimed at maximizing shared bike use.

Table 60 - Change in mode use: Scenario 3

clusters	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
1: PT + bike	33,1%	-7,8%	-12,6%	11,3%	33,4%	-1,7%	6,9%
2: Car mostly	18,0%	7,9%	-14,9%	5,6%	21,9%	-0,5%	8,0%
3: Bike + car	15,7%	9,5%	-21,9%	11,9%	7,1%	-1,3%	4,8%
4: PT + car	22,5%	9,5%	1,6%	-3,3%	12,0%	-2,8%	0,7%
5: Shared	19,6%	-6,0%	-1,8%	13,4%	12,2%	0,0%	12,4%
Potential absolute changes	29%	-3%	-14%	-33%	28%	-2%	9%

When maximizing shared bike use is set as the objective, it would strongly be increased mostly by people in cluster 1. They would also increase their train use by 33,3%. People in cluster 2 would also strongly increase both shared bike and train use. The largest drop in car use as a result of this bundle can be expected from people in cluster 3; the bike + car users.

Table 61 - Adoption rates: Scenario 3

€350	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
yes	**17,8%**	5,1%	4,9%	7,8%	16,4%
no	82,2%	94,9%	95,1%	92,2%	83,6%

Table 62 - Absolute changes in mode use population: Scenario 3

	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
with cluster 5	4,3%	-0,8%	-0,8%	-5,3%	4,4%	-0,2%	1,3%
without cluster 5	4,3%	-0,7%	-0,8%	0,6%	4,2%	-0,2%	0,7%

When taking adoption into account however, it can be seen that this bundle is not very popular among most clusters except 1 and 5. The absolute impacts are therefore much smaller as can be seen in Table 62. Shared bike use would still approximately increase by 4,4%, but car use would only decrease by 0,8%. Train use would increase by 4,3%. All other effects are smaller than 1%.

7.2.4 Scenario 4 –Maximize off-peak travelling

Below, the results are shown when the objective is set to maximize off-peak travel.

Table 63 - Changes in mode use: Scenario 4

Clusters	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
1: PT + bike	11,7%	19,6%	-0,3%	11,7%	17,4%	-3,3%	-1,8%
2: Car mostly	12,4%	18,7%	-2,8%	6,1%	11,3%	-4,4%	5,7%
3: Bike + car	20,1%	13,7%	-6,2%	6,1%	9,8%	-2,8%	2,7%
4: PT + car	-3,5%	13,7%	3,1%	5,5%	14,7%	-6,3%	-6,0%
5: Shared	19,3%	0,0%	-11,2%	9,0%	0,4%	0,8%	0,3%
Potential absolute changes	7%	17%	-3%	9%	13%	-4%	0%

Table 64 - Peak hour avoidance: Scenario 4

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
yes	63,7%	53,1%	20,6%	29,9%	29,9%
no	36,3%	46,9%	79,4%	70,1%	70,1%

Cluster 1 would increase off-peak travelling mostly, and at the same time they would increase train use by 11,7%. Also BTM, Shared car, and Shared bike use would be significantly increased by this cluster. Cluster 3 would increase train travel mostly, and at the same time decrease car use quite substantially.

Table 65 - Adoption rates: Scenario 4

€275	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
yes	18,5%	22,8%	1,0%	**24,7%**	21,5%
no	81,5%	77,2%	99,0%	75,3%	78,5%

Table 66 - Absolute change mode use: Scenario 4

	Train	BTM	Car	Shared Car	Shared Bike	Bike	Taxi
with cluster 5	1,2%	3,2%	-0,4%	1,9%	2,7%	-0,6%	-0,1%
without cluster 5	1,1%	3,3%	-0,3%	1,9%	3,2%	-0,7%	-0,1%

When looking at adoption levels, it can be seen that this bundle is relatively popular among most clusters, except cluster 3. No other bundles showed such uniform high levels of adoption across the clusters. Nonetheless, absolute levels of change in mode use are quite low, with barely any impact on absolute levels of car use.

8 CONCLUSION & DISCUSSION

This chapter answers the research question that was formulated in the introduction: *What are the effects of Mobility as a Service bundles on the travel behavior of travelers in the Netherlands, and how do these effects relate to public policy goals?* Key findings are presented in section 8.1. In section 8.2 the implications of the results are discussed, and policy recommendations are given. In section 8.3 it is discussed how the results of this research relate to other research. In section 8.44 the limitations of the research are addressed, followed by suggestions for further research in section 8.5.

8.1 KEY FINDINGS

The starting point of this research was that MaaS may have the potential to transform the transport system by changing travel behavior. The hopes and expectations of policy makers are that car dependency will decrease and travel behavior will become more sustainable as a result of MaaS. There is however limited quantitative data available that supports or refutes this claim. Therefore, the aim of this research was to assess the effects of MaaS bundles on the travel behavior change, in order to better understand the overall impacts of MaaS on the transport system. In order to assess the effects of MaaS this research therefore constructed and distributed a survey in which a stated choice experiment, and a stated adaptation experiment were integrated based on MaaS bundle configurations adapted to the Dutch context. In the survey, current travel behavior of respondents, the impacts of different MaaS bundles on their travel behavior, and the extent to which they were willing to adopt MaaS bundles were measured. 203 respondents completed the survey.

Multiple regression analyses revealed that MaaS bundles have the strongest effects in decreasing car use for people already using other modes besides car. Increased train travel as a result of MaaS is expected mostly from people already using train. BTM use on the other hand is surprisingly expected to be increased mostly by current car users if unlimited access to it is provided. The research has also shown that increased shared car use, as a result of integrating cheaper access to it in the bundle, is expected mostly from people that do not, or not often use their car currently. Next to that, increased taxi use is expected mostly from people that use public transport. Looking at peak-hour avoidance, limited potential for increasing peak-hour avoidance was found in the current study. The group most willing to increase their off-peak travel is the PT + bike user group. Result of the investigation which MaaS bundle configurations have influences on car-shedding, it was found that MaaS is not yet a valuable alternative for car owners. For non-car owners, MaaS would only be an alternative for car ownership if unlimited train and BTM are included as bundle elements. It was however also shown that MaaS bundles with unlimited components lead to an induced total trip frequency, especially for current public transport users, and bike + car users. Results from the stated choice part of the survey revealed that the most important attributes for adoption are respectively unlimited use of train travel or unlimited off-peak travelling and cheap access to shared cars. Shared bikes, BTM and free taxi trips were Current PT users were found to be the most likely adopters of MaaS. Strict car users are the least likely adopters of MaaS.

8.2 IMPLICATIONS

Taken together, the findings of this research suggest that the expected effects of MaaS bundles on improving sustainability and reducing congestion will be very limited, if not contradictory. This is due to the fact that MaaS propositions as they were proposed in this research are not interesting enough for car-users, hence reduced car use will be limited. The bundles would however rather spark interest with current public transport users. Nevertheless, the travel behavior of these people would likely become less sustainable, as MaaS would lead to an increased use of car-based modalities such as shared-cars and taxi. As was stated in the introduction, MaaS providers will most likely make most of their money from making people travel with these types of services, rather than from public transport. It can thus reasonably be expected that MaaS providers will exploit the tendency of some potential users to shift away from public transport towards on-demand modes. The (limited) reduced levels of car use by MaaS adopting car-users would therefore at least to some extent be compensated by the increased levels of car-based modality use.

Nonetheless, this research showed that MaaS bundles, when not relying on adoption at market prices, have the potential to change travel behavior towards more sustainable ways. Respondents were told to imagine how they would change their travel behavior if they were handed the bundle by for example their employee. Even frequent car users indicated that they would reduce car-use and increase the use of public transport with certain bundle configurations. Also the use of shared modes can be increased substantially by including them in bundles. These results thus suggest that MaaS bundles may in fact be used as a mobility management tool in order to stimulate certain travel behavior.

In order to align MaaS impacts with public policy goals, relying on market outcomes will thus probably not be sensible. The findings of this study provide insight for an active governance role for governments wishing to steer MaaS in a more desirable way. Based on the results in this study, achieving a better alignment between the impacts of MaaS and public policy goals can be achieved in two ways. First of all, MaaS adoption should be made more attractive for current car-users. Secondly, the unintended consequences of public transport users shifting towards more car-based modalities needs to be prevented. Different policy recommendations for both policy goals will be discussed below.

First of all, stimulating adoption of MaaS among people that currently travel in less sustainable ways seems like a right starting point. Since from this research it can be concluded that the level of experience with shared modes and public transport is a good indicator for the willingness to travel more often with these modes, and to adopt MaaS, it could be a reasonable approach to give people the opportunity to try out new behavior. This is referred to as trialability in literature about adoption of innovations (Rogers, 2003). The degree to which an innovation may be experimented with is positively correlated with the rate of adoption. Measures that can be thought of are allowing people to trade in their car for a number of months while receiving free MaaS bundles, or receiving a large discount on their first couple of months of MaaS usage.

Adoption among car users could furthermore be increased if employers would be stimulated to cooperate. Employers play a decisive role in the type of travel behavior their employees engage in. Providing people with lease cars is frequently found to make people car dependent. It would therefore better to instigate company policy which promotes more sustainable alternative. MaaS bundles could offer an alternative for providing the employee with their mobility needs. A problem with lease cars is however that they are a fiscally attractive option for the company, and the employee. Currently, MaaS would be less fiscally attractive, because income tax has to be paid over the mobility budget. Policy should therefore be aimed at favoring multi-modal travel options for employers, over the provision of lease cars.

Besides stimulating adoption among car owners, the second identified option, and probably the most important one, to better align the impacts of MaaS with policy goals is to reduce the negative side effects that were found to be occurring under a MaaS future. In order to limit the effects of increased use of car-based modalities, such as shared cars and taxi, by public transport users, but also increased crowding during peak-hours, it is suggested to instigate dynamic pricing measures. MaaS provides an ideal tool to build in sophisticated pricing measures defined by time of day, geography and modal efficiency (Hensher, 2017). This way, providers that are offering services making use of government provided assets (the road), will have to charge their users extra for using car-based modalities. This ensures that more efficient modes will be favored. This is especially needed if car use will drop in price in an autonomous future. However, these measures are at odds with a unlimited use bundles, which are preferred by potential users. Moreover a more active governance role is required to ensure this outcome.

8.3 COMPARISON TO OTHER RESEARCH

This thesis has been one of the first attempts to thoroughly examine the impacts of MaaS bundles on changing travel behavior. Recently an article (still in press) by Storme, De Vos, De Paepe, & Witlox (forthcoming) about the potential of MaaS as a substitute for car ownership in Belgium also found similar results to this study. In a small pilot very limited effects of MaaS being a substitute for private car ownership were found. Moreover, the researchers concluded that MaaS will probably not reduce car use.

The present study are also consistent with a recently published article about the likeliness of using MaaS among Dutch residents in the Hague (Fioreze, de Gruijter, & Geurs, 2019). This research found that likeliness of adoption MaaS is relatively low (approximately 20%). The study also found that current travel behavior was an important determinant of willingness to use MaaS. The results are also in line with a study by Alonso González et al. (2018) in which it was found that more multi-modal travelers were more likely to adopt MaaS.

8.4 LIMITATIONS

Several important limitations of this research have to be discussed, since they affect the way these results should be interpreted.

First of all, as MaaS is not yet a solidified concept, decisions were made as to how the concept would look like in a possible near future. The fixed characteristics of the bundles were based on the nine core characteristics by (Jittrapirom et al., 2017). These were explained to the respondent in order to prevent them from making their own assumptions about MaaS. It could however still have been that respondents did not fully understand the concept of MaaS. A video-link with a clear explanation was provided in case respondents needed further explanation, but experience with other research tells that respondents do not wish to open video’s in surveys. It is therefore expected that not many people did this.

Next to that, trade-offs had to be made in the construction of the experimental design in order to limit the response burden of the survey. This meant that only the attributes that were deemed most important could be included in the experiment, in order to prevent the survey from becoming too long. The experimental design was therefore based on only differing the design characteristics, which were taken to be the levels of access to the integrated transport modes. This meant that the MaaS bundles were constructed based on currently existing transport modes, and correspondingly on currently existing propositions. This also meant that the concept of MaaS had to be kept fairly narrow. The whole idea of MaaS is however that it fully integrates all services related to mobility. Services that one could think are for instance the upgradeability of transport modes (for example bigger cars, other types of shared-(e)bikes etc.) but also services such as providing parking information, integration of P2P car-sharing and even integration with charging facilities. Since these could not be included in the design characteristics, it could be that respondents do not fully grasp the potential user benefits of MaaS. Furthermore, it could therefore not be assessed to what extent novel propositions would be attractive for users, or in what way they contribute to changing travel behavior.

The survey still took on average 12 minutes to complete however. This may have caused attention to go for the choice tasks near the end. In order to limit these effects, the bundle order was presented randomly to the different respondents. Nonetheless, the survey had a drop-out rate of 40%. This is quite high. Possible reasons could be that the survey was quite long. Even though the estimated response time was based on the completion time of multiple people, it could have been that the subject matter was quite complex for some people, and therefore it took them longer, which caused them to drop out. Also due to the complexity of the survey a risk exists that only people who think they understand MaaS quite well completed the survey. This may have caused the unrepresentativeness of the sample in terms of education level.

Another reason for the unrepresentativeness of the survey can be the way of distributing. The majority of the respondents were recruited through the personal network of the author through social media platforms and through direct emails. Another major contributor the spreading of the survey was the personal network of the supervisors of the author. These are not representative of the entire population.

Another limitation of this research has to do with the measurement levels of travel behavior change. Respondents were asked to assess on a five point ordinal scale to what extent they would increase or decrease mode use, and total number of trips made. Even though a quantitative indication was given as to what percentages were related to the increase and decrease in mode use, this is still a very subjective answer option. Different respondents could therefore have had different perceptions about what 'a little bit more' for instance meant. This may have resulted in biased results.

Moreover, the research only measures what people say they would change, which does not necessarily have to mean they would actually change their behavior like that. This hypothetical bias is always present in stated preference research. It is however expected that assessing behavioral changes are even more difficult to predict than whether or not the decision would be made to buy a product. It is therefore questionable to what extent behavioral changes would actually occur.

Also, because only 203 respondents completed the survey and the experimental design was blocked into four blocks, only about 50 replications of the entire design were completed. This has impacts on the reliability of the estimated parameters. Many of the parameters were not statistically significant. Especially when the datafiles were split in order to execute separate regression analyses per cluster, this could be problematic. The cluster differences and the absolute impacts should thus rather be seen as an indication, and not as exact values set in stone.

Since a stated choice experiment and a stated adaptation experiment were integrated into one experiment, both experiments could only partially be executed. Normally, in a stated adaptation experiment respondents can answer freely how they would envision they'd change their behavior. In this experiment, the questions were not open-ended. This may have caused changes in behavior that could potentially occur to be missed. Additionally, in a stated preference experiment, respondents usually have to choose a preferred option between two or more choice alternatives. In this experiment, they could only indicate whether or not they would be willing to adopt the bundle.

Therefore, less information about the trade-offs of the respondents could be obtained, leading to less reliable parameters.

With regards to the data analysis, there are also some limitations. The stated choice model was estimated based on the MNL model. This is computationally easy and quick. However, the model ignores panel effects, and assumes that unobserved attributes of alternatives are not correlated. It thus treats each observation as a separate individual, hence it assumes that each observation obtains the same amount of information in trade-offs. It could however be that specific respondents have specific preferences, and therefore always have a base preference in their choices. Moreover, the different MaaS options are however all MaaS options, and are therefore possibly correlated. This could be account for by applying a mixed logit model for instance.

8.5 FUTURE RESEARCH

The issue of studying the impacts of MaaS is an intriguing one which could be usefully explored in further research. First of all, since MaaS is still a developing concept, it is sensible to experiment further with different propositions of MaaS bundles in order to get a better picture of the attributes people find important, and what their effects on travel behavior change are. Especially helpful could be to acquire these insights with revealed preference data in the form of pilots. This way the hypothetical bias could be reduced as well. The scope of future research could furthermore be extended with the inclusion of to flexible pay-as-you-go propositions as well.

For future stated preference research it would be a good idea to pivot the offered MaaS bundles on current travel behavior of respondents. In this research, everyone was shown the same bundles, but since people’s travel behavior differ, sometimes the offered bundle does not completely cover the individual’s transport needs. Next to pivoting the bundles around the respondent’s travel behavior, it would be a good idea to give respondents an indication of their monthly travel costs based on this current travel behavior. This would give a more informed decision whether or not to buy a MaaS bundle.

Future research should also seek a larger sample that is more representative of the population. That way, more generalizable results can be obtained that more accurately estimate total changes.

Also more qualitative research should be performed in order to get a better understanding of underlying reasons for people choosing or not choosing certain bundles, so that MaaS propositions can be better finetuned to individual needs.

In order to deal with the limitations of the estimated stated choice models, future research should focus on estimating more advanced models. Mixed logit models can deal with the shortcomings of the MNL model that was used in this research.

Another idea for future research would be to estimate latent class regression models. This way, the respondents are clustered based on their response pattern on the dependent variables, rather than clustered based on their current travel behavior. By including current travel behavior as covariates, the influence of current travel behavior and extent of travel behavior change can still be determined, but latent class regression models are expected to perform better in terms of model fit.

As this research showed that travel behavior change can direct in less sustainable behavior, a challenge for future research furthermore lies in experimenting with measures that aim to direct people towards more favorable travel behavior when using MaaS.

8.6 Scientific contribution

This study took a first step in the estimation of the effects of MaaS bundles on the travel behavior of travelers in the Netherlands. A novel way of estimating the effects was applied by integrating a stated choice experiment and a stated adaptation experiment. The bundles were specifically adapted to the Dutch transport context. This has not yet been done before and therefore the research contributes to the scientific body of knowledge about MaaS bundles and their impacts. Clustering the respondents based on current travel behavior, and then continuing the analyses based on this classification proved to be a valuable addition in the determination of absolute effects with this integrated experiment.

8.7 Social contribution

The research shows that even though change in travel behavior can be expected, the overall effects on the transport system are limited. It thus provides a more realistic insight into the total effects one can expect from implementing MaaS. This provides food for thought as to what can be done about limiting negative effects, and increasing positive effects.

8.8 Practical contribution

In this research it was shown which types of travelers find MaaS propositions attractive. MaaS providers can learn from this in order to better construct propositions for certain target groups.

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Appendix A. EXPERIMENTAL DESIGN

	0	1	2	3
Rail (a)	Always discount	Weekend free, and off-peak discount	Free off-peak and weekend	Unlimited travelling
Taxi/ride-hailing (b)	0 trips up to 5km	2 trips up to 5km	4 trips up to 5km	6 trips up to 5km
Costs (c)	50	175	300	425
Car-sharing (d)	€4 / hour + €0,29 / km	€3 / hour + €0,24 / km		
BTM (e)	Always discount	Unlimited travelling		
Bike (f)	€1,00 per trip up to 40 minutes	Unlimited trips up to 40 min		
Transferability of credits (g)	No	Yes		

Design								
Choice situation	alt1.a	alt1.b	alt1.c	alt1.d	alt1.e	alt1.f	alt1.g	Block
1	0	2	0	1	1	1	1	2
2	3	0	2	1	1	1	0	4
3	0	3	2	1	1	0	0	3
4	2	2	3	1	0	0	0	1
5	3	2	2	0	0	0	1	4
6	3	3	0	0	0	1	0	1
7	2	1	1	0	1	0	0	4
8	1	0	1	1	0	0	1	3
9	0	1	2	0	0	1	1	3
10	1	2	1	0	1	1	0	3
11	3	1	0	1	1	0	1	1
12	1	1	3	1	0	1	0	2
13	1	3	3	0	1	0	1	2
14	2	3	1	1	0	1	1	4
15	2	0	3	0	1	1	1	1
16	0	0	0	0	0	0	0	2

Attributes and levels

	0	1	2	3
Costs (a)	€50	€175	€300	€425
Rail (b)	Altijd voordeel (20% spits, 40% dal)	Weekendvrij en dalkorting	Dalvrij en weekendvrij	Altijd vrij
Taxi/ride-hailing (c)	Geen taxi/uber ritten	2 ritten tot 5km	4 ritten tot 5km	6 ritten tot 5km
BTM (d)	Altijd voordeel (20%)	Altijd vrij		
Car-sharing (e)	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	€3 / hour + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)		
Bike (f)	€1,00 per rit tot 40 minuten	Onbeperkt gratis ritten tot 40min		
Transferability of credits (g)	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand		

Block 1

	a	b	c	d	e	f	g
A	€300	Dalvrij en weekendvrij	6 ritten tot 5km	Altijd vrij	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand
B	€425	Altijd vrij	Geen taxi/uber ritten	Altijd voordeel (20%)	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand
C	€425	Weekendvrij en dalvoordeel	Geen taxi/uber ritten	Altijd vrij	€3 / uur + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand
D	€300	Altijd voordeel (20% spits, 40% dal)	6 ritten tot 5km	Altijd voordeel (20%)	€3 / uur + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand

Block 2

	a	b	c	d	e	f	g
A	€50	Dalvrij en weekendvrij	Geen taxi/uber ritten	Altijd vrij	€3 / uur + €0,24 / km	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand
B	€175	Weekendvrij en dalvoordeel	6 ritten tot 5km	Altijd vrij	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand
C	€175	Altijd vrij	6 ritten tot 5km	Altijd voordeel (20%)	€3 / uur + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand
D	€50	Altijd voordeel (20% spits, 40% dal)	Geen taxi/uber ritten	Altijd voordeel (20%)	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand

Block 3

	a	b	c	d	e	f	g
A	€50	Altijd vrij	4 ritten tot 5km	Altijd vrij	€3 / uur + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand
B	€175	Altijd voordeel (20% spits, 40% dal)	2 ritten tot 5km	Altijd vrij	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand
C	€50	Weekendvrij en dalvoordeel	4 ritten tot 5km	Altijd voordeel (20%)	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand

D	€175	Dalvrij en weekendvrij	2 ritten tot 5km	Altijd voordeel (20%)	€3 / uur + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand

Block 4

	a	b	c	d	e	f	g
A	€425	Altijd voordeel (20% spits, 40% dal)	4 ritten tot 5km	Altijd vrij	€3 / uur + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand
B	€425	Dalvrij en weekendvrij	4 ritten tot 5km	Altijd voordeel (20%)	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand
C	€300	Weekendvrij en dalvoordeel	2 ritten tot 5km	Altijd voordeel (20%)	€3 / uur + €0,24 / km Voorbeeld: Dagje uit €29,70 (bij 60km, 5 uur)	€1,00 per rit tot 40 minuten	Ongebruikte ritten kunnen niet meegenomen worden naar de volgende maand
D	€300	Altijd vrij	2 ritten tot 5km	Altijd vrij	€4 / uur + €0,29 / km (voorbeeld: dagje uit €37,40 bij 60km, 5 uur)	Onbeperkt gratis ritten tot 40min	Ongebruikte ritten kunnen wel meegenomen worden naar de volgende maand

Appendix B. DATA PREPARATION

Partial results were filtered out of the data file

It was checked whether all responses had unique response ID's and therefore only emitted the survey once. Each ID occurred only once

The answers to questions in the category 'other, namely' were checked to see if they fitted existing answers. This was the case with one respondent who indicated that his education level was 'doctoraal' which corresponds to the current WO Master, and was therefore added to that category.

The attribute levels were added to the dataset.

In the original data output of SurveyGizmo, each respondent corresponded to one line, with the answers to the questions in column. Moreover, all questions about the different choice sets were put in a new column. Since each respondent received four choice tasks, the data was processed in order to have each respondent assigned to four different rows, and their answers to the questions assigned to the same columns.

A new variable column was created for age. This was calculated by subtracting the birth year from the current year

Variables were defined in SPSS (ordinal/nominal/scale)

Variable labels were added to the variables

Missing values were listed

Appendix C. TESTING THE REPRESENTATIVENESS OF THE SAMPLE

Table X.1 – Gender distribution in the Netherlands (CBS Statline, 2019) and in sample.

	Man	Vrouw	toaal
Nederland	8.527.041 (49,63%)	8.654.043 (50,37%)	17.181.084
Observed distribution sample	127 (64,10%)	71 (35,90%)	198
Expected distribution sample	98	100	
Diference	29	-29	

Gender	
Chi-square value	16,99
Degrees of freedom	1
p-value	0.001

There are more men in the sample than expected from the population. This is a statistically significant difference. Therefore the sample is not representative in terms of gender.

Table X.2 Age group distribution in the Netherlands (CBS Statline, 2019) and in the sample.

Ages	15-20	20-25	25-45	45-65	65-80	80+
Population	6,1%	6,2%	24,6%	28%	14,6%	4,6%
Sample percentage	0%	14,6%	51%	31,3%	2,5%	0,5%
observed	0	29	101	62	5	1
Expected	12	12	49	55	29	9
Difference	-12	17	52	7	-24	-8

Age	
Chi-square value	171
Degrees of freedom	5

p-value	0

The sample is statistically different in age groups compared to the population. The youngest age group is underrepresented. The 20-25 age group is overrepresented. The age group between 25-45 is quite well represented, as well as the age group 45-65. The oldest age groups are underrepresented.

	Low	Medium	High
Population	16.30%	27.10%	56.60%
Sample	0	0	198
Expected	32	54	112
Difference	-32	-54	86
Education level			
Chi-square value		152	
Degrees of freedom		1	
p-value		0	

The sample is not representative. The full sample is highly educated.

Appendix D. FINAL SURVEY DESIGN

Geachte heer, mevrouw,

Hartelijk dank voor uw deelname aan deze enquête.

Deze enquête wordt uitgevoerd als onderdeel van mijn afstudeeronderzoek aan de Technische Universiteit Delft, in samenwerking met Royal HaskoningDHV. De resultaten worden gebruikt voor onderzoek naar een nieuw mobiliteitsconcept genaamd: Mobility as a Service (MaaS). In de rest van de enquête zal **MaaS** als afkorting gebruikt worden. Het doel van de enquête is om inzicht te krijgen in de verwachtte gedragseffecten van, en voorkeuren voor MaaS abonnementen. Uw mening wordt hierbij zeer gewaardeerd.

De enquête bestaat uit vier delen. Het invullen ervan zal **ongeveer 8-10 minuten kosten.** Deelname is volledig anoniem, en u kunt zich op ieder moment terugtrekken uit de enquête zonder hier een reden voor te geven.

Mocht u nog vragen of opmerkingen hebben, kunt u met mij in contact komen

Rein de Viet
rein.de.viet@rhdhv.com

ID: 3

1. Hoe vaak maakt u gebruik van een **privé auto** (zowel als bestuurder als passagier) *

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

ID: 7

2. Hoe vaak maakt u gebruik van een **deelauto** (zoals GreenWheels, SnappCar, ConnectCar, Car2Go etc.) ? *

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

ID: 12

3. Hoe vaak maakt u gebruik van de **trein**? *

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

ID: 8

4. Hoe vaak maakt u gebruik **van de bus, tram en/of metro**? *

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

ID: 9

5. Hoe vaak maakt u gebruik van **uw eigen fiets?** *

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

ID: 10

6. Hoe vaak maakt u gebruik van een **deelfiets** (zoals OV fiets, MoBike, DonkeyRepublic etc,) ? *

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

ID: 11

7. Hoe vaak maakt u gebruik van diensten zoals de **taxi en/of Uber**? *

- (vrijwel) elke dag
- 5-6 dagen per week
- 3-4 dagen per week
- 1-2 dagen per week
- 1-3 dagen per maand
- 6-11 dagen per jaar
- 1-5 dagen per jaar
- minder dan 1 dag per jaar

ID: 13

8. Met welk vervoersmiddel legt u de **grootste afstand** af in een gemiddelde week?
(het gaat hierbij om alle verplaatsingen die u maakt, dus als u vaak 1km fietst naar een treinstation, om daarna 50km met de trein te reizen, kies dan 'trein') *

- Privé auto
- Zakelijke lease auto
- Trein
- Bus/tram/metro
- Motor
- Brommer/scooter
- Fiets/elektrische fiets
- lopen
- Anders namelijk: ______

ID: 313

9. Heeft u een rijbewijs? *

- Nee
- Ja

ID: 311

10. Hoeveel auto's bezit uw huishouden? *

- Geen
- 1
- 2
- Meer dan 2

ID: 322

11. Kunt u altijd over een auto beschikken? *

- Ja, wanneer ik maar wil
- Nee, dat gaat in overleg met mensen binnen mijn huishouden
- Nee, dat gaat in overleg met mensen buiten mijn huishouden
- Nee, (vrijwel) nooit

ID: 321

12. Krijgt u de woon-werk reiskosten die u maakt vergoed? *

- Nee
- Ja gedeeltelijk
- Ja
- Ik heb geen woon-werk reiskosten

ID: 314

13. Heeft u een openbaar vervoersabonnement (zoals NS businesscard, studentenreisproduct, NS flex etc.) *

- Nee
- Ja

ID: 315

14. Welke situatie is het beste op u van toepassing? *

- Mijn belangrijkste vervoersmiddel is de zakelijke lease-auto
- Mijn belangrijkste vervoersmiddel is mijn privé auto
- Mijn belangrijkste vervoerswijze is het openbaar vervoer
- Ik reis het meest op andere manieren

ID: 16

Mobility as a Service - Gebruik in plaats van bezit

MaaS is een nieuw mobiliteitsconcept, waar de vraag naar mobiliteit vanuit de gebruiker centraal staat. Tegenwoordig zijn er talloze aanbieders van mobiliteitsdiensten. Denk hierbij aan het openbaar vervoer, deelconcepten zoals deelauto's, scooters en fietsen, Uber, uw eigen auto enzovoorts.

Het MaaS concept koppelt al deze verschillende diensten naadloos aan elkaar op 1 platform, bijvoorbeeld via een app. Op deze MaaS app plant u eenvoudig een reis zoals u gewend bent (zoals bijvoorbeeld met 9292OV of Google Maps). In één overzicht krijgt u vervolgens te zien op welke mogelijke manieren de reis gemaakt kan worden. Of dit nu met de fiets, uw eigen auto, het openbaar vervoer, een deel-auto, deelfiets, taxi of een combinatie hiervan is. Met dezelfde app kunt u de reis ook reserveren, boeken, betalen en krijgt u toegang tot de verschillende diensten.

Doordat MaaS rekening houdt met uw persoonlijke voorkeuren, de beschikbaarheid van de diensten, file's, parkeermogelijkheden etc., draagt het bij aan meer reisgemak en lagere kosten per reizigerskilometer. Doordat u daarnaast compleet ontzorgd wordt in het maken van een deur-tot-deur reis vormt het een aantrekkelijk alternatief voor een eigen auto, of stelt het u in staat uw eigen auto iets vaker te laten staan.

Voor een vast bedrag per maand kan een abonnement aangeschaft worden waarmee u in meer of mindere mate gebruik kunt maken van de verschillende diensten. Maakt u onverwachts toch meer gebruik van bepaalde diensten? Dan kunnen altijd credits bijgekocht worden.

Indien u verdere uitleg wenst over het concept, verwijzen we u graag door naar het volgende filmpje

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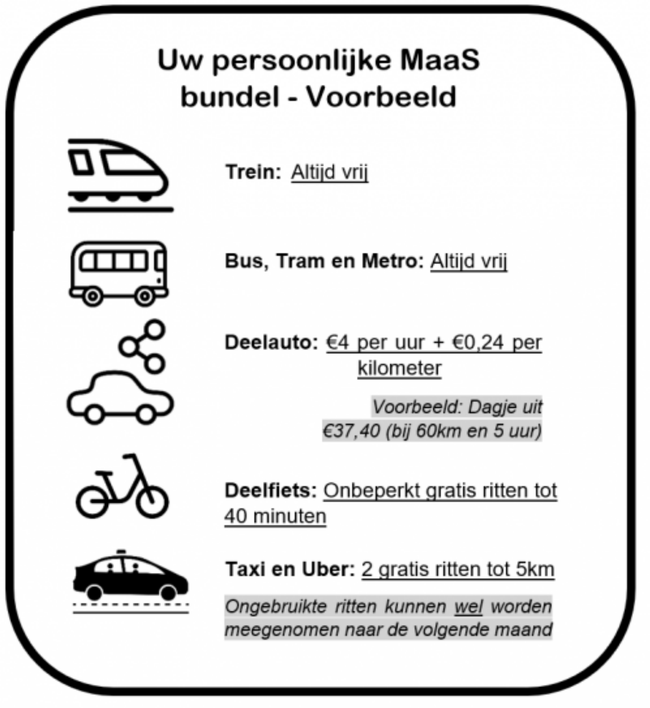
In het volgende deel van de enquête zullen vier maandelijkse MaaS abonnementen getoond worden. Over elk abonnement zal een aantal vragen gesteld zal worden.

Hieronder volgt een uitleg over de maandelijkse MaaS bundels. Gelieve deze instructiepagina goed doorlezen.

De maandelijkse bundels die getoond gaan worden kunnen er als volgt uitzien:

Let op dit is een voorbeeldbundel



De uitleg van de bundel is als volgt:

- **Trein:** geeft toegang tot alle treinen in Nederland. Varieert tussen
  - 'altijd vrij': hiermee kunt u altijd gratis reizen met de trein binnen Nederland
  - dalvrij en weekendvrij': hiermee kunt u gratis reizen tijdens de daluren en in de weekenden (De daluren zijn op werkdagen van 0.00 - 6.30 uur, van 9.00 - 16.00 uur en van 18.30 - 24.00 uur)
  - 'dalvoordeel' en 'weekendvrij: hiermee kunt met 40% korting reizen tijdens de daluren, en gratis in het weekend.
  - altijd voordeel': hiermee kunt u met 20% korting tijdens de spits reizen, en met 40% korting tijdens de daluren.
- **Bus/tram/metro:** geeft toegang tot alle bus, tram, metro en veerpont diensten waar u ook gebruik van kunt maken met uw OV chipkaart in Nederland. Varieert tussen:
  - altijd 20% korting
  - altijd vrij.
- **Deelauto:** geeft toegang tot alle deelauto-aabieders (zoals Greenwheels, Snappcar, Car2go, Connectcar etc.) Hierdoor heeft u altijd toegang tot een auto bij u in de buurt. De kosten zijn inclusief brandstof. De deelauto kunt u achterlaten op locatie. Varieert tussen:
  - 4 euro per uur + 0,29 cent per kilometer
  - 3 euro per uur + 0,24 cent per kilometer.
- **Deelfiets:** geeft toegang tot alle deelfietsaanbieders (zoals OVfiets, Mobike, DonkeyRepublic, Keobike etc). hierdoor heeft u altijd toegang tot een fiets bij u in de buurt. Deze kunt u achterlaten op bestemming. Varieert tussen:
  - '1 euro per rit tot 40 minuten',
  - en 'onbeperkt gratis ritten tot 40 minuten'.
- **Taxi en uber:** geeft toegang tot alle taxi bedrijven, en afroepbare taxidiensten zoals uber. Varieert tussen
  - 'geen' graits ritten per maand
  - '2' gratis ritten per maand tot 5 km
  - '4' gratis ritten per maand tot 5 km
  - '6' gratis ritten per maand tot 5 km
- **Meeneembaarheid taxiritten:** geeft optie om niet gebruikte taxiritjes mee te nemen naar de volgende maand. Varieert tussen
  - wel meeneembaar naar de volgende maand
  - niet meeneembaar naar de volgende maand

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Voor het beantwoorden van de vragen, vragen wij u zich in eerste instantie in te beelden dat u het desbetreffende maandelijkse bundel van uw werkgever krijgt. U kunt nog steeds gebruik maken van uw lease-auto, maar daarnaast ook van de andere mobiliteitsdiensten via uw persoonlijke MaaS bundel.

1. Als eerste zijn we benieuwd óf, en hoe u uw mobiliteitsgedrag zou veranderen in die situatie, ten opzichte van uw huidige gedrag. Dat wordt gevraagd voor ieder vervoersmiddel.

De antwoordopties zullen kwalitatief van aard zijn. U heeft de keuze uit:

- **Veel minder**
  - dit houdt in dat in dat u tenminste 50% keer minder vaak gebruik zult maken van deze vervoersoptie
- **Een beetje minder**
  - Dit houdt in dat u tussen de 0 en 50% minder vaak gebruik zult maken van deze vervoersoptie
- **Hetzelfde**
  - Deze antwoordoptie houdt in dat u uw gedrag niet zou veranderen t.o.v. uw huidige gedrag
- **Een beetje meer**
  - Dit wil zeggen dat u tussen de 0 en 50% vaker gebruik zult maken van deze vervoersoptie
- **Veel meer**
  - Dit houdt in dat u tenminste 50% keer vaker gebruik zult maken van deze vervoersoptie
- **N.v.t**
  - U kunt deze antwoordoptie aanvinken als u momenteel deze vervoersoptie niet gebruikt, en niet zult gebruiken in de toekomst.

2. Daarna vragen we of u zelf geïnteresseerd zou zijn om de bundel aan te schaffen voor een gegeven prijs.

3. Als laatste zijn we benieuwd of u alsnog een lease-auto denkt nodig te hebben, indien u de bundel bezit.

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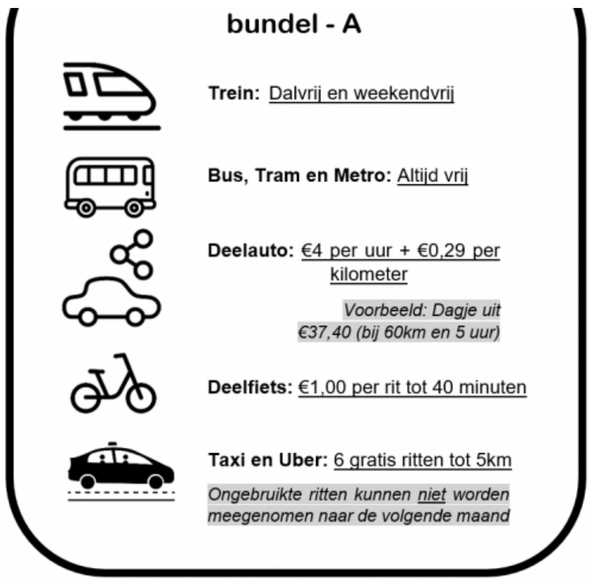
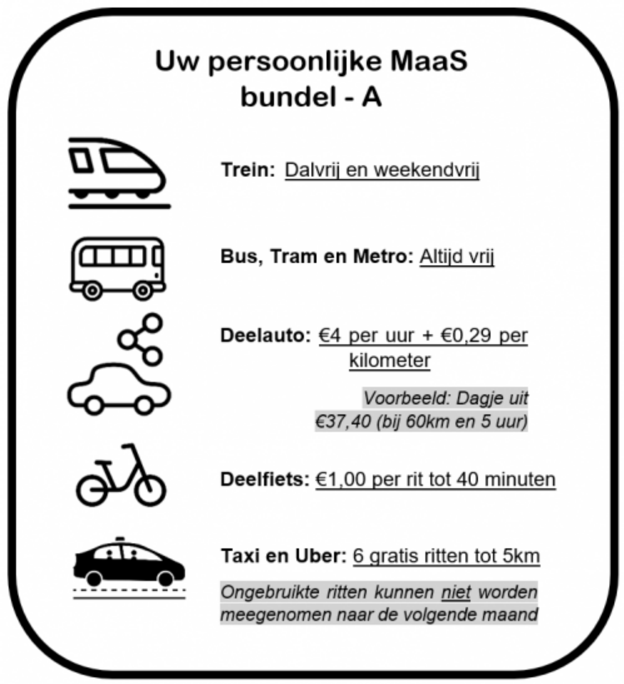


Indien u deze maandelijkse bundel zou krijgen, in welke mate zou u dan uw reisgedrag aanpassen met de volgende vervoersmiddelen? *

	Veel minder	Een beetje minder	Het zou gelijk blijven	Een beetje meer	Veel meer	N.v.t
Trein						
Bus/tram/metro						
Deelauto						
Privé auto						
Deelfiets						
Uw eigen fiets						
Taxi/uber						

ID: 29

16.



Indien u deze bundel zou krijgen, zou u dan overwegen vaker buiten de spits te reizen? *

- Nee
- Ja

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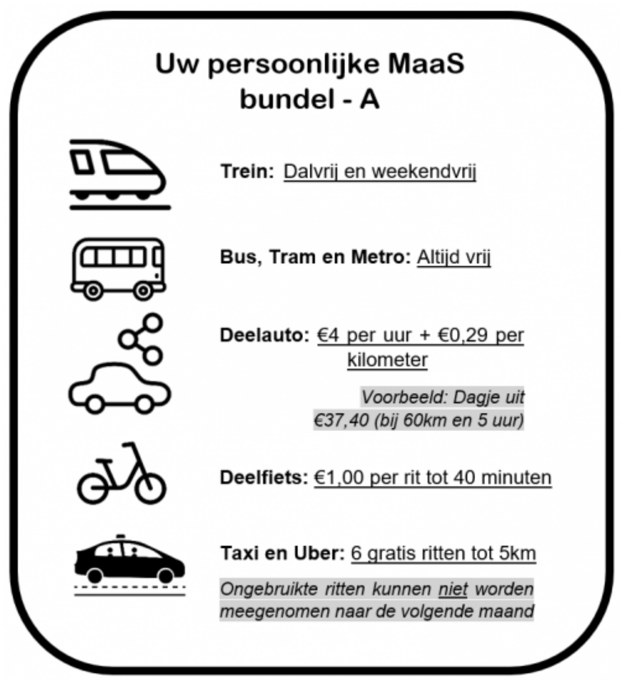
17.



Indien u deze bundel zou krijgen, zou u dan in totaliteit meer of minder trips maken in een gemiddelde week, ongeacht het vervoersmiddel?

Bijvoorbeeld minder trips door vaker thuis te werken, of juist meer trips door vaker op bezoek te gaan bij een vriend of familie. *

Veel minder	Een beetje minder	Hetzelfde	Een beetje meer	Veel meer
○	○	○	○	○

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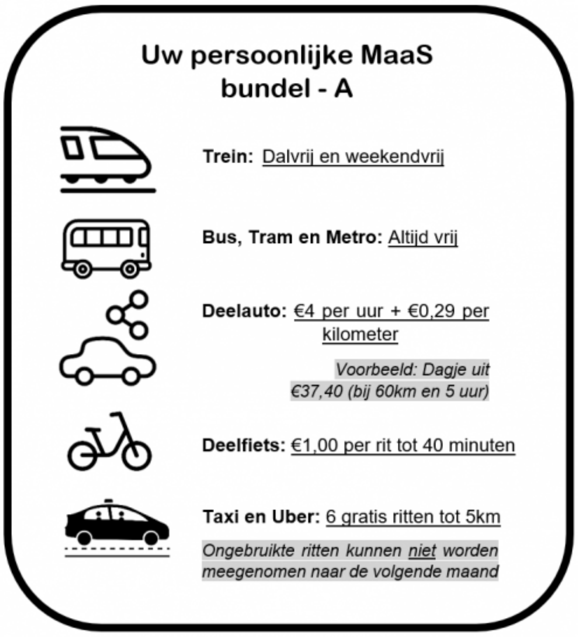
18.



Als deze bundel zou worden aangeboden voor € 300 per maand, zou u het dan overwegen zelf aan te schaffen? *

- Nee
- Ja

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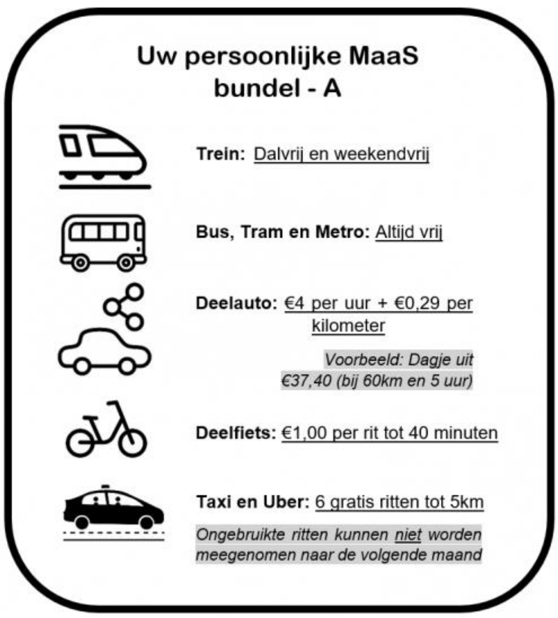


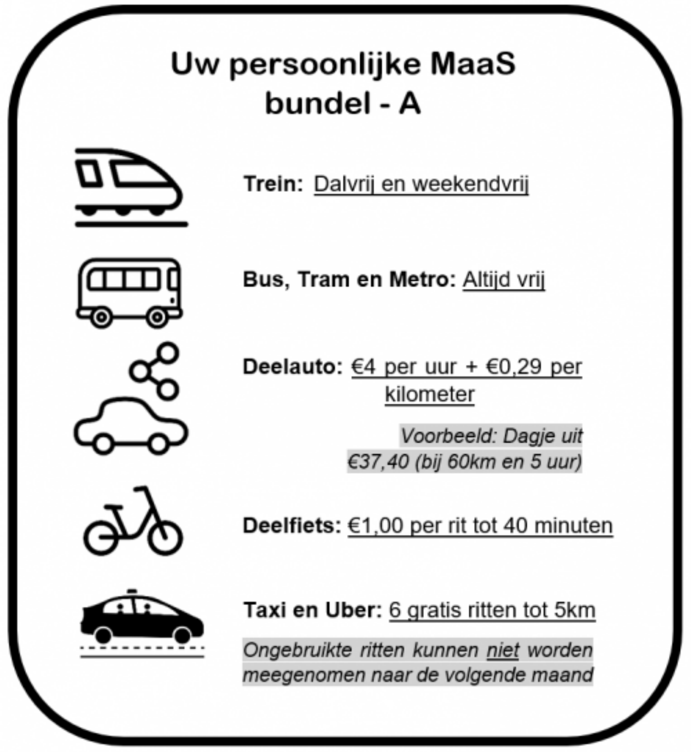
Zou u overwegen uw auto weg te doen als u deze bundel zou worden aangeboden?

Gemiddeld kost een compacte middenklasse auto 499 euro per maand (inclusief afschrijving, belasting, verzekering, onderhoud, brandstof)

** De berekeningen zijn op basis van 10 jaar en 11.500 km per jaar.* *

- Nee
- Ik zou mijn tweede auto wegdoen
- Ik zou mijn enige auto wegdoen

ID: 46



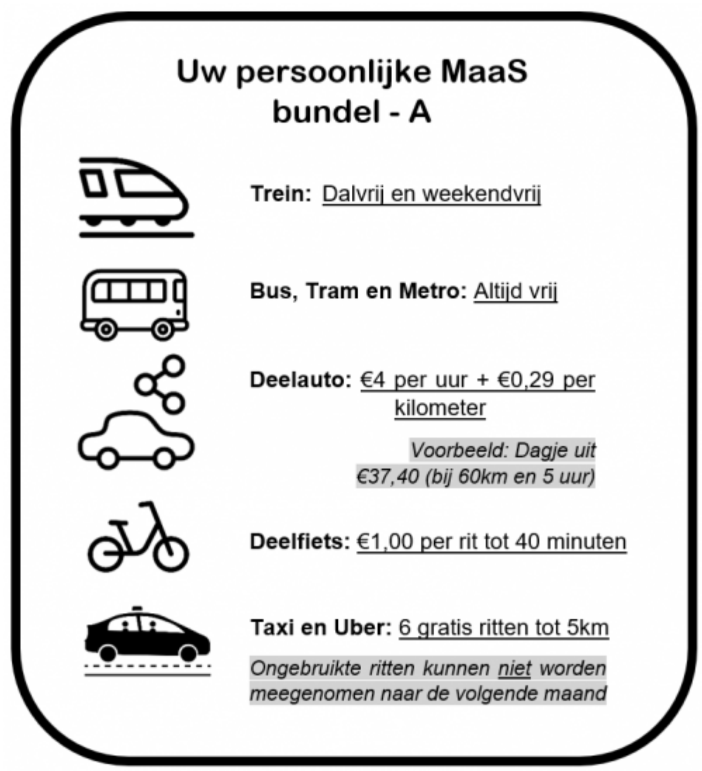
Zou u in de toekomst toch nog een auto willen aanschaffen, als u deze bundel zou worden aangeboden?

Gemiddeld kost een compacte middenklasse auto 499 euro per maand (inclusief afschrijving, belasting, verzekering, onderhoud, brandstof)

** De berekeningen zijn op basis van 10 jaar en 11.500 km per jaar.* *

- Ja
- Nee, ik zou de aankoop van een tweede auto niet doen, of uitstellen
- Nee, ik zou geen auto kopen, of de aankoop uitstellen

ID: 47



Zou u naast deze bundel alsnog een lease-auto willen, ook al moet u daar extra kosten voor maken? *

- Nee
- Ja
- Ja, mits het niet meer is dan ..... euro per maand [ ]

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(dit gaat zo door volgens het experimentele design)

123. Wat is uw geslacht? *

- Man
- Vrouw

ID: 149

This question has answer validation View Conditions

124. Wat is uw geboortejaar? *

ID: 278

125. Uit hoe veel personen bestaat uw huishouden? (woningdelen telt niet als meerpersoons huishouden) *

- 1
- 2
- 3
- 4
- 4+

ID: 279

126. Hoe zou u uw woonomgeving beschrijven? *

- Landelijk perifeer
- Landelijk bereikbaar
- Dorps
- Centrum dorps
- Buiten centrum kleinstedelijk
- Centrum kleinstedelijk
- Buiten centrum grootstedelijk
- Centrum grootstedelijk

ID: 316

127. Wat is uw huidige werksituatie? *

- Student/scholier
- Part-time in dienst
- Full-time in dienst
- Ondernemer
- Werkeloos, op zoek naar een baan
- Werkeloos, niet op zoek naar een baan
- Met pensioen

ID: 151

128. Wat is uw hoogst afgeronde opleiding? *

- Lagere school
- VMBO/MAVO
- HAVO
- VWO
- MBO
- HBO Bachelor
- WO Bachelor
- WO Master
- PhD
- Anders

ID: 148

129. Wat is het totale bruto jaarinkomen van uw huishouden?
*

- minder dan 10.000 euro
- 10.000 - 20.000 euro
- 20.000 - 30.000 euro
- 30.000 - 40.000 euro
- 40.000 - 50.000 euro
- 50.000 - 60.000 euro
- 60.000 - 70.000 euro
- 70.000 - 80.000 euro
- 80.000 - 90.000 euro
- 90.000 - 100.000 euro
- meer dan 100.000 euro
- zeg ik liever niet

Hartelijk dank voor uw deelname aan dit onderzoek.

Mocht u nog vragen en/of opmerkingen hebben of graag een exemplaar ontvangen van het eindresultaat, dan kunt u mailen naar rein.de.viet@rhdhv.com

ID: 1

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