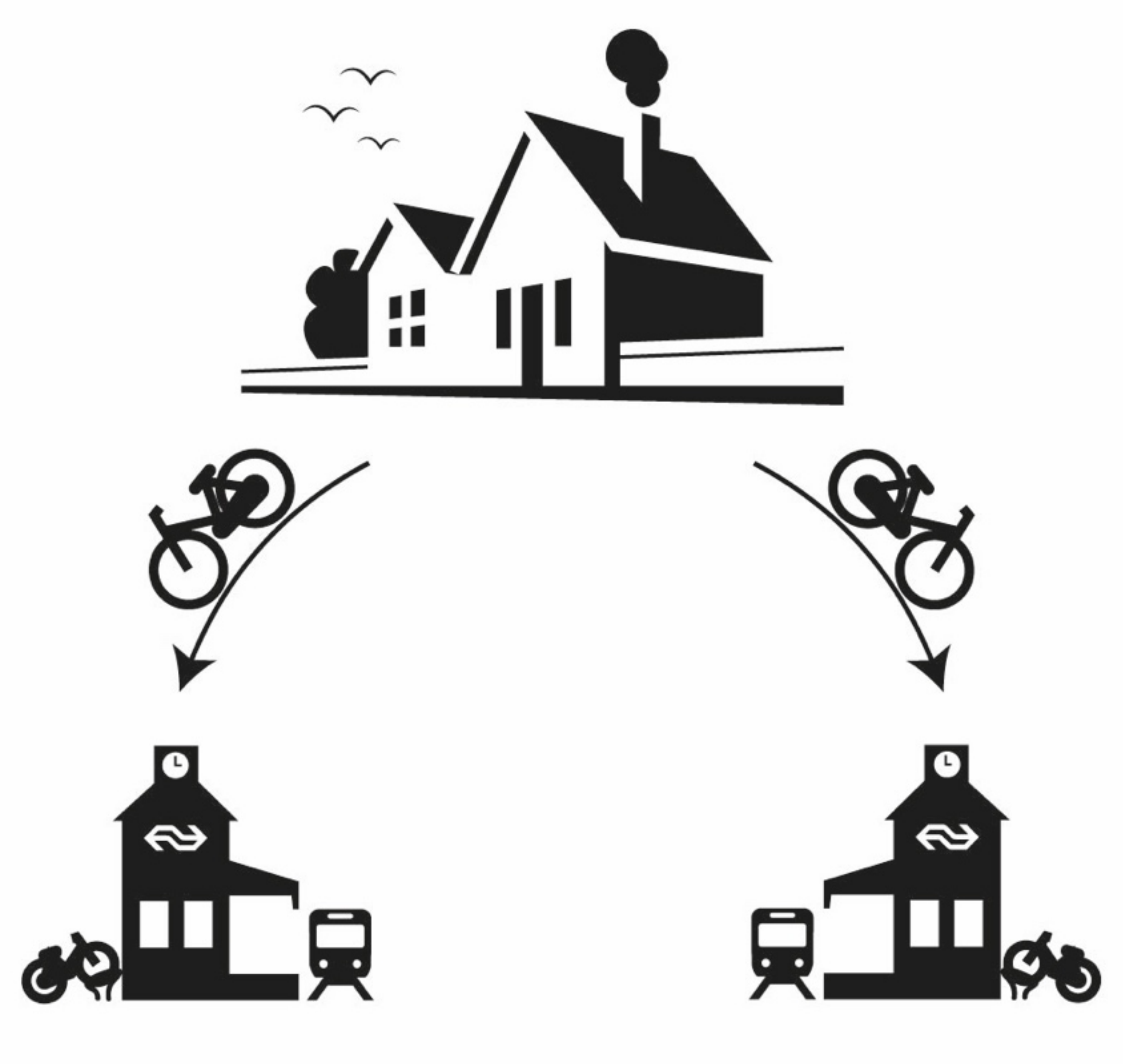
Influencing station choice of cyclists

An innovative solution to reduce bicycle parking pressure at railway stations



Graduation thesis for the master Transport, Infrastructure and Logistics

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Preface

Seven months ago, I started this research on the station choice of travelers accessing a station by bike, a subject that made it possible to contribute to science and practice. In front of you is the result of this study.

This document is the final piece, finalizing seven years of studying at University. In 2010 I started my bachelor in Urban and Regional Planning at the University of Amsterdam. During my bachelor I did a minor at the TU Delft, which was the trigger to start a master study in Delft. I have always been very happy with this decision and it was worth the numerous train trips between Amsterdam and Delft.

I appreciate all the help and support that has been given to me while writing this thesis, especially from the graduation committee that provided me of valuable feedback. Many thanks to Niels van Oort, who brought me in contact with the ministry and helped me draw the first ideas for this research. I want to thank Jan Anne Annema for his valuable advice and enthusiasm and Bert van Wee for his detailed comments, and sharing some of his extensive research experience. Also Conny Broeyer, for her advice and guidance during the last 7 months, and of course for showing me the modus operandi of the ministry.

Many thanks to all the colleagues at the ministry who made me feel welcome, and for everyone that participated in this research, as a respondent to the survey or as an interviewee. It would not have been possible to finish this study without them. Last but not least, I want to thank my friends for all their support, and my parents for always supporting me whatever road I choose to take.

Enjoy reading this thesis.

Joeri van Mil

Amsterdam, 5 April 2017

Summary

The bicycle is a popular access mode for the train. Together, the train and bike are seen more and more as a combination mode: the bicycle train mode. Their characteristics complement each other in an excellent way. The use of this combination has a lot of benefits for accessibility, health and society. However, the rise of the bicycle in combination with the train has a backside. At more and more railway stations this leads to overcrowded bicycle parkings. The upswing of the bicycle is being seen as something good that should continue. However, extending capacity is not always possible within limited budgets, and therefore innovative solutions are necessary. Influencing station choice in order to spread parking pressure is one of those innovations. This study researches this innovation on parking pressure.

There has not been done much research yet into influencing station choice, nor into the process that takes places when a station choice is made. Research has been done into the valuation of time and costs of trip parts; this knowledge is useful, but it has not been studied yet within the context of station choice. To influence station choice, knowledge about the factors that play a role in that choice is required. To fill this knowledge gap and to see how station choice can be influenced this study is set up. This led to the main research question: *On what factors do 'bicycle-train' travelers base their station choice when accessing the railway network, how are those factors related and what are measures to influence this choice based on those factors?*

This question has a fundamental part and a part that is focused on generating policy. The answering of the fundamental part was split up in several stages. Because the available knowledge on station choice was scarce, the factors that play a role in station choice had to be explored. This exploration was based on literature supplemented by the experience of bicycle users. No distinction in impact of the factors was made yet. Some factors had an overlap because they influenced each other completely or partly. Dependencies were mapped, leading to a pure list of factors that have influence on one of the trip parts: access part, station part and train part. Besides the factors that directly influence the trip parts there are also factors that influence the valuation of those direct factors. Those are the personal characteristics of the users and the context variables like weather and trip purpose. The factors are shown in Figure 1.

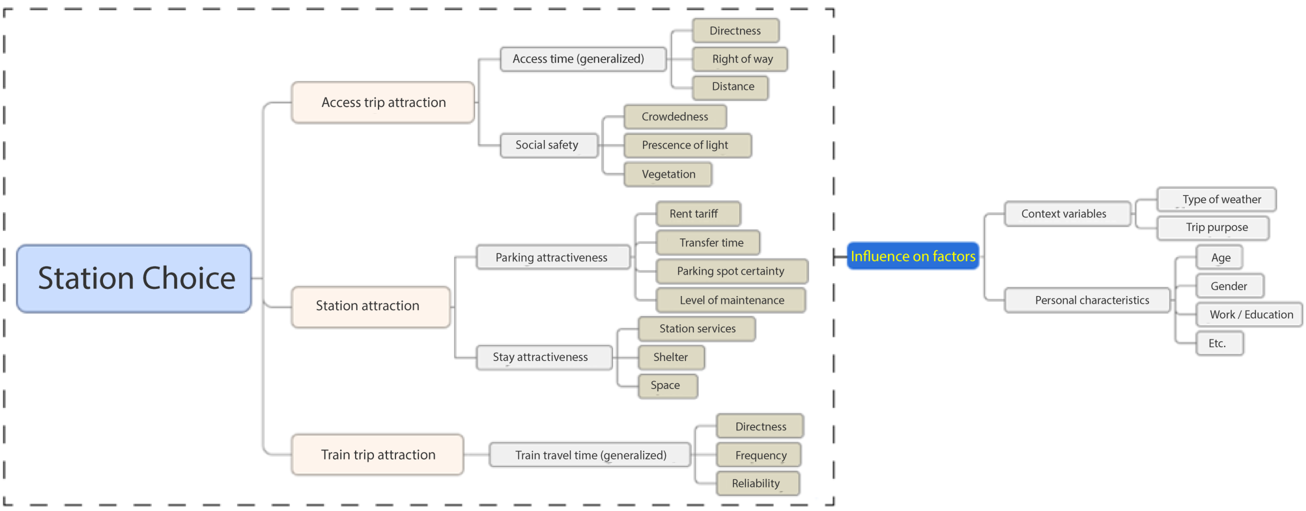


Figure 1 - Factors that influence station choice

To acquire knowledge about how those factors relate, a stated preference experiment was set up. Stated preference has the benefit that an experiment can be created in the optimal way for the researched attributes. Every respondent makes his choices based on the same situation. The disadvantage is that respondents must emphasize with a situation that they are not familiar with. Nevertheless, stated preference best fits the goals of this study. There was a maximum number of five factors that could be included in the choice experiment, therefore a selection had to be made of the list of factors. In order to do this, 20 bicycle train users were asked to rank the factors. Out of this ranking the most influential factors were selected to be included in the choice experiment. It was important to include the strongest factors in the choice experiment because they provide the most information and it avoids dominant alternatives in the choice set. The factors were bicycle time, time to park and go to the platform, train time, parking price and transfer (in the train).

The experiment was conducted by distributing a survey. This survey consisted of 3 parts. First the personal characteristics and habits of respondents were presented; the reason for this was to observe the impact of those characteristics on the factors. Then the choices were presented. Respondents had to choose between two stations that differed on the five factors. To each respondent 9 choices were presented. At the end, a few extra questions were asked to check how people interpreted the questions. The survey was distributed at stations and via social media. A total of 269 respondents completed the survey, of whom most were acquired through social media. To analyze the data a Multinomial Logit Model (MNL) was used. The outcomes of this model are the dependencies between the included factors.

The outcomes show what the strength of the factors is in the station choice process. Because a monetary factor was included (parking price) this can be used to calculate a value of time or willingness to pay. This made it possible to validate, since there is research available in that field. Furthermore, it is also an understandable way to show the impact of the factors on station choice. The values are shown below:

Bike time:	€0.11 per minute
Time to Park:	€0.08 per minute
Train time:	€0.08 per minute
Transfer:	€0.60 per transfer

Monetizing the factors is not the only way to interpret the outcomes; it is possible to use any unit to show the interdependencies. So, for example comparing bike time with the other components. Figure 2 shows that 1 minute of bike time is equal to €0,11 of parking costs, 1.4 minute of time to park, 1.4 minute of train time and one fifth of a transfer. This means that someone is willing to cycle an extra 5 minutes (e.g. to an intercity station) to avoid a transfer. This knowledge can be used to alter the attractiveness of a station. A different attractiveness results in a different station choice.

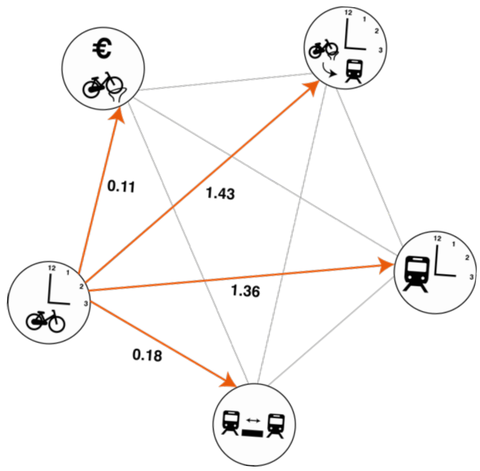


Figure 2 – Bike time relating to other factors

The analysis per personal characteristic and habit shows that the differences between age categories are quite high, while trip purpose and the number of trips per week has a much smaller effect on the outcomes. The outcomes were validated by comparing them to existing research about value of time and willingness to pay, and by showing the results to experts. This showed that the outcomes were in general valid.

After determining the influence of factors, a new research stage began. The factors were presented to different stakeholders and experts. The respondents were asked in semi structured interviews to come up with measures to spread parking pressure based on the parameters that were acquired in the fundamental stage. They came up with a set of possible measures. This set was subdivided in measures that impact one of the three trip parts, or a combination of them. An example of a measure is changing the railway schedule to make some stations more attractive. The interviewees were also asked about the pros and cons of those measures. To value the different measures, they were rated (by the author) on two aspects: effort to implement and effect on influencing. By comparing ratings the potential for implementation of a measure was calculated (1 = most, 3 is least). The set of measures is shown in Table 1.

Table 1 - Measures to influence station choice and their potential for implementation.

Category	Measure	Potential for implementation
Access trip	Stretching routes	3
	Right of way	2
At the station	Pricing	1
	Pricing (reducing free time)	1
	Rewarding	1
	Parking close to platform	1
	Easy access and fast lanes	2
Train trip	Change schedule (more stops)	2
	Increase speed	3
Combination	Increase Information	2

To illustrate the impact of measures some of them were implemented in a case. The case was the station choice between Amsterdam Zuid and Amsterdam RAI. By taking pricing measures and making adaptions to the schedule it is possible to make Amsterdam RAI more attractive for certain users than Amsterdam Zuid. This shows that it is possible to influence the attractiveness of a station and therewith the choice for a station.

This study was executed with certain assumptions and within a limited time frame. Therefore, it was not always possible to use the optimal methods or the perfect number of respondents, in particular in the steps in preparation of the choice experiment. The respondents in this study were not entirely a reflection of the (bicycle-) train users. although there were also similarities: highly educated people are overrepresented both in the data and in the population of bicycle train users. Some of the differences might have lead to overestimation, where others have lead to underestimations. Still, validation showed that the outcomes of the choice experiment are plausible. This might be an indication that overestimation and underestimation compensated each other.

To build further based on the lessons learnt in this thesis, a set of recommendations for further research is composed. It is advised to execute an experiment like this with a larger number of respondents and with more factors included. If a larger study is not possible the data of this study can be used for further analysis, for example on zip code level. In the preparation of this thesis it was discovered that there is some research available about the attractiveness of stations, this thesis adds an extra piece to that puzzle. It would be valuable to execute a meta-analysis to combine all research. It is also advised to explore all factors that play a role in station choice in an extensive empirical study. And as a last recommendation the measures that were found in this thesis were rated 'quick and dirty'. It would be valuable to let a larger group of experts rate them.

This thesis shows that there is potential for influencing station choice. Several recommendations for practice are given. The true potential can be examined by starting a pilot. It would be most logical to start implementing measures that have the lowest effort to implement and the highest impact. It is therefore advised to start with pricing measures. The other recommendations are to build new parking's as close as possible to the platforms (at stations where cyclists should be drawn to) and to start a discussion about redesigning the railway schedule, with more stops on secondary stations, because it has a lot of potential.

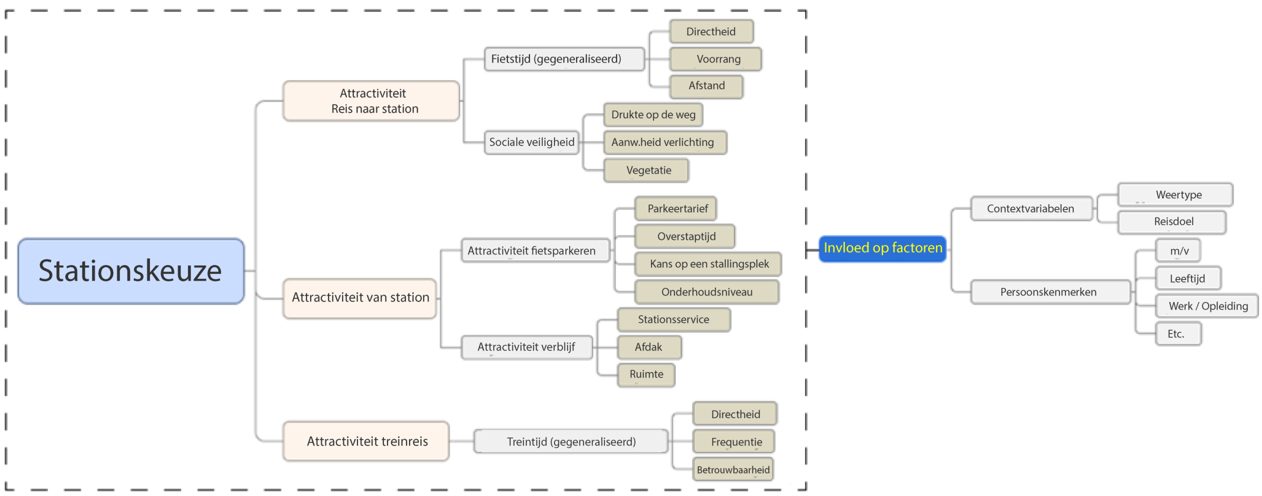
With this two-stage study valuable insights on station choice fundamentals are gained and potential measures to influence station choice are presented. Influencing station choice can become an innovative solution for parking problems at railway stations.

Samenvatting

De fiets is een veel gebruikte manier om bij het station te komen. De trein en fiets worden steeds meer gezien als een combinatiemodaliteit: de fiets-trein. De eigenschappen van beide modaliteiten vullen elkaar perfect aan. Dat deze modaliteit aan populariteit wint heeft veel voordelen op het vlak van bereikbaarheid, gezondheid en maatschappij. De populariteit van de fiets-trein modaliteit heeft echter ook nadelen. Bij steeds meer stations zorgt het toenemende gebruik van de fiets voor parkeerdruk in de stallingen. Toch is het vanwege de voordelen belangrijk om de fiets-trein combinatie te blijven stimuleren. Het bijbouwen van capaciteit is echter niet altijd mogelijk binnen de beschikbare budgetten. Innovatie oplossingen zijn nodig. Het beïnvloeden van stationskeuze om de druk op stallingen te spreiden is een van deze innovaties. Deze studie onderzoekt de mogelijkheden hiervoor.

Er is nog niet veel onderzoek gedaan naar het beïnvloeden van stationskeuze, noch naar het gedragswetenschappelijke aspect van het maken van die keuze. Er is wel onderzoek gedaan naar de waardering van tijd en de kosten van verschillende onderdelen van een reis. Deze kennis is waardevol, maar mist de context van stationskeuze. Om de keuze te beïnvloeden moet eerst duidelijk worden hoe stationskeuze werkt. Dit heeft geleid tot de volgende onderzoeksvraag: *Op welke factoren baseren fiets-trein reizigers hun stationskeuze als ze richting het station gaan, hoe verhouden deze factoren zich tot elkaar en welke maatregelen kunnen genomen worden om deze keuze te beïnvloeden?*

Deze vraag heeft een fundamenteel onderdeel en een onderdeel dat gericht is op het genereren van beleidsmaatregelen. Het fundamentele onderdeel is weer verder opgesplitst. Omdat de beschikbare kennis over stationskeuze beperkt bleek moesten eerst de factoren die een rol spelen in stationskeuze in kaart gebracht worden. Hiervoor is literatuur gebruikt, aangevuld met de input van ervaren fiets-trein gebruikers. Hierbij geen onderscheid gemaakt tussen de impact van factoren op stationskeuze. Door de afhankelijkheden in kaart te brengen ontstond er een duidelijke lijst van factoren, waarbij een onderscheid gemaakt is in het onderdeel van de reis dat ze beïnvloeden: naar het station, op het station en met de trein. Daarnaast zijn er nog factoren die de stationskeuze niet direct beïnvloeden, maar die de waardering beïnvloeden. Dit zijn de persoonskenmerken van reizigers en de contextvariabelen als weer en reisdoel. De factoren en hun afhankelijkheden zijn weergeven in Figuur 3.



Figuur 3 - Factoren die de stationskeuze beïnvloeden

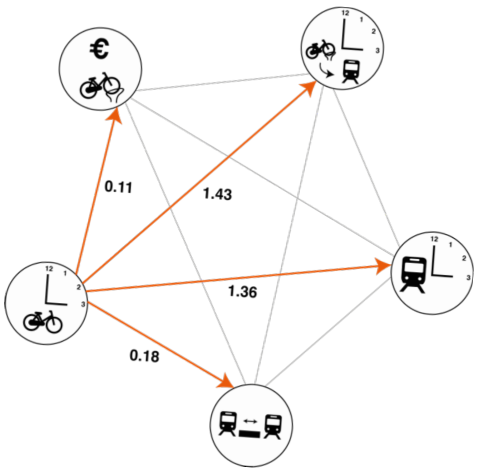
Om de relatie tussen de factoren in kaart te brengen is een 'stated preference' onderzoek opgezet. De methode maakt het mogelijk om een experiment optimaal aan te laten sluiten bij de onderzochte factoren. Iedere respondent maakt een keuze die gebaseerd is op precies dezelfde situatie. Hier staat tegenover dat respondenten een context moeten bedenken die ze niet kennen. Ondanks dat sluit deze methode het best aan bij de onderzoeksdoelen. Maximaal 5 factoren konden meegenomen worden in het onderzoek, daarom is er een selectie gemaakt. Via een 'ranking' zijn de 5 belangrijkste factoren geselecteerd. Deze ranking is uitgevoerd door 20 fiets-trein gebruikers. Het meenemen van de sterkste factoren is van belang omdat die het meeste invloed hebben op stationskeuze, daarmee leveren ze ook de meeste informatie op. De sterkste factoren zijn fietstijd, tijd om te parkeren en naar het perron te gaan (parkeertijd), treintijd, stalprijs en het aantal overstappen.

Het experiment is gestart met het rondsturen van een enquête. De enquête bestond uit drie onderdelen: een onderdeel met de persoonskenmerken en reiskarakteristieken, de 9 keuzes waarmee uiteindelijk de relatie tussen de factoren bepaald is en wat extra vragen om de interpretatie van de vragen te controleren. De enquête is verspreid bij stations en via sociale media. Om de data te kunnen analyseren is een 'multinomial logit model' (MNL) gebruikt. De uitkomsten van dit model geven de afhankelijkheden en relaties tussen de 5 factoren weer.

De uitkomsten van het experiment laten zien wat de invloed van de factoren is bij een stationskeuze. De monetaire factor (stalprijs) kan gebruikt worden om de andere factoren een monetaire waarde te geven. Dit maakt het bovendien mogelijk om de uitkomsten te valideren aan de hand van bestaand onderzoek naar 'value of time'. Daarnaast is het een begrijpelijke manier om duiding te geven aan de uitkomsten. De waarden zijn hieronder weegeven:

Fietstijd:	€0,11 per minuut
Parkeertijd:	€0,08 per minuut
Treintijd:	€0,08 per minuut
Overstap:	€0,60 per overstap

Het monetariseren van de factoren is niet de enige manier om ze te interpreteren. Iedere eenheid kan gebruikt worden om de afhankelijkheden duidelijk te maken. Bij het vergelijken van fietstijd met de andere factoren (Figuur 4) wordt duidelijk dat 1 minuut gelijk staat aan €0,11 voor stallen, 1,4 minuut parkeertijd, 1,4 minuut treintijd en een vijfde van een overstap. Dit betekent dat iemand bereid is om 5 minuten extra te fietsen om een overstap te voorkomen. Deze inzichten kunnen gebruikt worden om de aantrekkelijkheid van een station bij te stellen. Een aangepaste aantrekkelijkheid leidt tot een andere stationskeuze.



Figuur 4 – Fietstijd ten opzichte van andere factoren

De analyse op basis van persoonskenmerken en reiskarakteristieken laat zien dat met name leeftijd veel impact heeft, hoe hoger de leeftijd, hoe hoger de waarde van tijd, terwijl reisdoel en het aantal reizen per week nauwelijks effect heeft op de uitkomsten. De uitkomsten zijn gevalideerd door ze te vergelijken met bestaande onderzoeken over tijdswaarde en door de uitkomsten voor te leggen aan experts. Dit liet zien dat de uitkomsten over het algemeen valide zijn.

Na het bepalen van de invloed van factoren via het stated preference experiment begon een nieuwe onderzoeksfase: het genereren van maatregelen. De factoren werden gepresenteerd aan verschillende stakeholders en experts. De respondenten werden in semigestructureerde interviews gevraagd om maatregelen te bedenken die stationskeuze zouden kunnen beïnvloeden, gebaseerd op de uitkomsten van de eerste onderzoeksfase. Hieruit ontstond een set met mogelijke maatregelen. De set is onderverdeeld in maatregelen die invloed hebben op een van de drie onderdelen van een reis, of op een combinatie daarvan. Een voorbeeld van een maatregel is het aanpassen van de dienstregeling en op meer stations te stoppen. De respondenten hebben ook de voors en tegens van de door henzelf genoemde maatregelen gegeven. Om de verschillende maatregelen op waarde te schatten heeft de auteur een rating gegeven op twee aspecten: inspanning om te implementeren en effect op de beïnvloeding. Door deze twee aspecten met elkaar te vergelijken is het implementatiepotentieel bepaald. De maatregelen zijn te vinden in Tabel 2 (1=meest, 3=minst).

Tabel 2 – Maatregelen om de stationskeuze te beïnvloeden inclusief implementatiepotentieel

Categorie	Maatregel	Implementatiepotentieel
Naar het station	Strekken van fietsroutes	3
	Voorrang geven	2
Op het station	Beprijzen	1
	Beprijzen (verkorten gratis staltijd)	1
	Belonen	1
	Stallingen dichtbij het perron	1
	Snelle toegang stalling	2
Treinreis	Aanpassen dienstregeling (meer stoppen)	2
	Snelheidsverhoging	3
Combinatie	Verbeteren informatievoorziening	2

Om de impact van maatregelen te illustreren zijn ze geïmplementeerd in een casus. De casus betreft de stationskeuze tussen stations Amsterdam Zuid en Amsterdam RAI. Door het nemen van beprijzingsmaatregelen en een aanpassing in de dienstregeling wordt Amsterdam RAI aantrekkelijker voor meer reizigers. Dit laat zien dat door het nemen van maatregelen stations aantrekkelijker gemaakt kunnen worden en daarmee dat de keuze voor een station te beïnvloeden is.

Deze studie is uitgevoerd met verschillende aannames en binnen een beperkte tijd. Om die reden was het niet altijd mogelijk om optimale methodes te kiezen of het perfecte aantal respondenten te verkrijgen. Dit speelde met name in de stappen om tot het stated preference experiment te komen. De respondenten in het experiment waren geen perfecte afspiegeling van de fiets-trein gebruiker. Sommige afwijkingen hebben mogelijk geleid tot overschatting van de uitkomsten, waar anderen mogelijk hebben geleid tot onderschatting van de uitkomsten. Er waren echter ook overeenkomsten, zo zijn zowel in de groep fiets-trein gebruikers als in dit onderzoek hoogopgeleide personen goed vertegenwoordigd. De validatie liet zien dat de uitkomsten valide zijn, dit kan erop duiden dat de overschatting en onderschatting elkaar gecompenseerd hebben.

Het uitvoeren van dit onderzoek heeft verschillende inzichten gegeven. Op basis hiervan worden verschillende aanbevelingen gedaan. Door in de toekomst een dergelijk stated preference experiment uit te voeren met meer factoren en respondenten kunnen nog betere uitkomsten worden gevonden. Als een uitgebreidere studie niet mogelijk is dan biedt de dataset die bij dit onderzoek opgebouwd is nog mogelijkheden voor een uitgebreidere analyse, bijvoorbeeld door de postcodedata te gebruiken. Bij het starten van het onderzoek werd duidelijk dat er wat, maar niet veel, onderzoek beschikbaar is dat gaat over de aantrekkelijkheid van stations in combinatie met de fiets. Deze scriptie kan een nieuw puzzelstukje zijn voor het in kaart brengen van dit onderwerp. Door het uitvoeren van een meta-analyse is het mogelijk om erachter te komen hoe deze stukjes in elkaar passen. Tot slot werden de maatregelen die stationskeuze kunnen beïnvloeden op een simpele manier gewaardeerd. Het zou waardevol zijn om deze waardering door een grotere groep experts uit te laten voeren.

Deze scriptie laat zien dat het beïnvloeden van stationskeuze potentieel heeft. De aanbevelingen voor gebruik van de maatregelen in de praktijk zijn als volgt: start een pilot waarbij begonnen wordt met de maatregelen die het meeste implementatiepotentieel hebben. Hiermee kunnen risico's en kansen beter in kaart gebracht worden. Verder wordt geadviseerd om nieuwe stallingen bij stations die aantrekkelijk gemaakt moeten worden zo dicht mogelijk bij het perron aan te leggen. Tot slot biedt een nieuwe dienstregelingsopzet, met meer halteringen op voorstadstations veel kansen om de parkeerdruk te spreiden. Het advies is om hier snel een discussie over te beginnen.

Deze studie heeft waardevolle inzichten gegeven in hoe stationskeuze werkt en hoe deze inzichten gebruikt kunnen worden om de stationskeuze te beïnvloeden. Het beïnvloeden van stationskeuze is een innovatie oplossing voor de fietsparkeerproblemen bij stations.

Index

1 Introduction

People are addicted to mobility. They have a widespread of modes to fulfill this demand. One of those modes is the train. This long distance mode requires an access or egress mode. Other forms of public transport can supply this, but the bicycle is also an option. The bicycle is becoming a more and more important access mode, but this results in parking pressure at certain railway stations. This study tries to come up with an innovative solution to reduce the pressure. It dives into the world of changing travelers' behavior. The central question being answered is: *On what factors do 'bicycle-train' travelers base their station choice when accessing the railway network, how are those factors related and what are measures to influence this choice based on those factors?* The answer to this questions gives us new insights about station choice but also provides a set of possible measures to spread parking pressure over different stations.

1.1 Problem statement

The expanding popularity of the bicycle as a connection mode results in high parking demands at stations (Van Boggelen, 2008). From a lot of perspectives this can be seen as a positive trend, but it has a backside. The overcrowding and capacity shortage this creates is a problem. When focusing on this problem it becomes clear that not every station has this problem. Sometimes because it is not a problem to extend capacity and sometimes because the parking demand is just low. The problem mainly occurs at stations where it is difficult to fit in new parking space (Kwink Groep, 2015).

When a certain station has a parking shortage this can have several causes. The first one is that due to growth or latent demand the capacity is not in line with demand of supposed user groups. The second cause is that parking's at station are misused (i.e. usage by non-train travelers, parking for other purposes like offices, residents, retail and leisure and usage as a bicycle graveyard).

According to the ministry of infrastructure and environment current policy is mainly focused on reducing overall travel time and improving door to door experience. The bicycle as a mode can help to improve this door to door experience, but only when the transfer with trains is attractive. To maintain its attractiveness, current interventions are focused on extending capacity and finding a solution for misuse. By preventing misuse, it is expected that about 25% of the capacity can be used more effective, because misuse makes room for appropriate users (VenW/NS, 2009). Current policy on a local level is focused on preventing a bicycle mess in public space near train-stations (Fietsberaad/Berenschot, 2012). This however brings extra pressure to the official[1] parking's around stations.

Considering the growth in bicycle parking demand it can be expected that dealing with misuse is not enough to cover the demand. However, to keep the bicycle-train mode attractive it is assumed that a parking should satisfy certain requirements (Van Boggelen, 2008). Those requirements are:

- 'acceptable' chance to find a parking spot
- Parking spot within walking distance, i.e. walking should feel as a part of the transfer, not as a trip itself.

[1] Official means everything that has the purpose of being used as a bicycle parking

When demand is higher than supply, it is impossible to fulfill these requirements (at any time of day). A possibility would be to increase capacity, which however is not always possible within limited budgets. Especially at stations where extra capacity is difficult to fit in due to limited space (Kwink Groep, 2015). Costs are getting too high to be carried by one party. This is thus not only a financial problem but also a governance problem. At this moment, the central government pays 50% of the costs, while the other 50% is paid by local and regional government. The operator of the station; the Dutch Railways (NS) generally doesn't pay for the investments, while their customers are mainly using the parkings (Berenschot, 2010). Because of this situation there is no incentive to generate income out of the parking that could be used for new investments. Therefore, at the moment funding is limited to available public funds.

The current situation is explained by the next enumeration:

- Bicycle-train use remains popular and stimulated, i.e. not fulfilling demand is not an option.
- The parking has to be in line with the requirements mentioned.
    - 'acceptable' chance to find a parking spot
    - Parking spot within walking distance, i.e. walking should feel as a part of the transfer, not as a trip itself.
- By preventing misuse and technical solutions the capacity of the parking is at its maximum efficiency level.
- Using public space as a bicycle park is no option since municipalities want to keep the public space open from an esthetic point of view.
- Building extra capacity up to demand is not always possible due to limited funding.

Those five points show that parking pressure remains a problem (1 and 2), but that if the most logic solutions are impossible or already used (3,4 and 5) innovative solutions must be found. Finding innovation is also a part of the agreement bicycle parking that was signed by several stakeholders (Ministerie van I&M; VNG; IPO; Stadsregio Amsterdam; Metropoolregio Rotterdam Den Haag; ANWB; ROVER; Fietsersbond; FMN; NS; ProRail, 2016). One of those innovative solutions is spreading the demand by moving some of the demand to other locations. Since this research is focused on bicycle-train, those other locations should be alternative train stations. Of course, a choice is not always present, but at the same time the parking pressure mainly occurs at large stations, and those stations have a larger chance of having an alternative station close by.

Since the demand comes from human beings this study has a behavioral focus. It focuses on the station choice that travelers have when they want to access the train system by bike. The next section shows some research has already been done into 'bicycle (as access mode) and influencing behavior. But there is not a lot of knowledge about the combination in the context of influencing station choice.

1.2 Background of the bicycle train mode

The bicycle as an access and egress mode to and from has become more and more popular in the Netherlands. This has its effect on station parkings. This section examines what is behind the rise of the bicycle in combination with public transport.

Currently around 47% of the access trips is by bike, and 13% of the egress trips is by bike (KIM, 2014). It has always been an option next to the standard modes like walking and car, however the last years a large increase of bicycle usage is observed (Buehler & Pucher, 2012). In the denser areas in the Netherlands use of the bicycle grew with 15% between 2011 and 2013 (CBS, 2014). Research has shown that the combination of train and bicycle can form a mode itself (Kager, Bertolini, & te Brömmelstroet, 2016). The special characteristics of both modes complement each other in such a way that the total outcome is higher than the sum of its parts. The bicycle is suitable for point to point connections on the short distance (KIM, 2015). Shelat, Huisman & van Oort (2017) showed that typical access distance for a cyclist to get to the train is 4km, while the egress distance is 2.7km. The train is suitable for hub to hub connections on the long distance. Together this can provide point to point connections on the long distance to achieve an attractive door to door journey.

This resurgent trend for the bicycle-train combination is welcomed due to its benefits, the accessibility benefits but also other benefits. The 5xE approach (Van der Bijl, Maartens, & Van Oort, 2016) is a way to show the value of public transport. Public transport contributes to Effective mobility, an Efficient city, Economy, Environment and Equity. The bicycle train mode can be seen as a form of public transport, therefore the 5xE also applies for this mode. It contributes to effective mobility because of the transport value and reliability. The bicycle train mode decreases congestion on road and in public transport feeder services, something that has proven to have impact in Haarlem, the Netherlands (Van Boggelen, 2008).

Bicycles and public transport consume less space than cars, which contributes to an efficient city. As a clean way of traveling it contributes to the environment, and because the mode doesn't require high personal investments it is accessible for a large share of society, this leads to equity. All those aspects lead to an attractive area, which has positive effects on the economy. Furthermore, the use of the bicycle also leads to health benefits (Woodcock, 2014). Improving quality of this mode will therefore not only benefit its users but will also benefit others and is therefore socially justifiable (Wardman & Tyler, 2000).

1.3 Research questions & methodology

The goal of this study is to get insight in the station choice process that travelers experience when they access the railway network by bike, and to find out how those insights can be used in practice. This is approached from a behavioral point of view i.e. what and how strong are the factors on what travelers base their stations choice. Those insights may lead to possible innovative solutions for overcrowding of bicycle parking's at railway stations. Within this thesis there will also be an explorative phase to find out whether the outlets of this research are usable in practice, to reduce parking problems.

1.3.1 Scope and context

The bicycle train mode has an access and an egress part, this also means that there can be two station choices per journey that furthermore influence each other. To make this research manageable in the amount of time and with the available resources some assumptions were made. Those assumptions lead to the scope and context of this research. First there is only a focus on the access part of the bicycle train trip. This means that the destination is fixed. It is assumable that the factors that influence station choice on the egress part have a large overlap with the factors influencing on the access part. Hence, combining two station choices would have made it very complex, while the outcomes would only slightly differ. Furthermore, this research is carried out in the Dutch context. This was an important starting point in the data acquisition, the Dutch respondents will imagine a trip in the Netherlands.

1.3.2 Research questions:

The main research question is:

On what factors do 'bicycle-train' travelers base their station choice when accessing the railway network, how are those factors related and what are measures to influence this choice based on those factors?

To answer the main research question five sub questions must be answered. Using sub questions brings structure to a study and has a positive effect on the repeatability. The sub questions are as follows:

1. What are the possible factors influencing station choice?
2. What factors are assumed to be most influential and measurable?
3. What is the influence of the factors on station choice?
4. What are possible measures to influence the factors and what are their pros and cons?
5. What would an implementation (in reality) look like?

1.3.3 Methodology

This study consists of two stages; the first stage is the fundamental research part and gives an answer to sub questions one to three. The second stage is focused on policy and implementations of solutions, and is based on the knowledge gained in the fundamental stage. This will give an answer to sub questions four and five. The methodology in this section is mainly introductive, more detailed choices are pointed out in the chapters were the sub questions are being discussed.

1.3.3.1 Fundamental research (stage 1)

Sub question 1 – What are the possible factors influencing station choice: This question has the goal to indicate what factors influence the decision for a station to cycle to. A *literature analysis* and *explorative interviews* provide the factors. For the literature analysis index software was first used, followed by snowball sampling (Noy, 2008). For the explorative sessions, some experienced cyclists were used as a source.

Sub question 2 – What factors are assumed to be most influential and measurable: With this question the identified influencing factors from sub question one are ranked on assumed impact. The possible factors were printed on cards and were presented to colleagues at the ministry whom are bikers themselves. The respondents were supposed to rank the cards. The interviewer was present when the cards are ranked. The benefit of this method is that possible ambiguities can be clarified (Bryman, 2008). Measuring the right influences is important for the experiments construct validity, when marginal factors are included in the experiment this could harm the outcomes (Bryman, 2008). To strengthen the card ranking, it was supplemented with an additional phase. Here a larger group of respondents were asked to rank their top 7.

Sub question 3 – What is the influence of the factors on station choice: Answering this question is based a quantitative *choice experiment.* This experiment has the goal to derive the impact (utility) of the factors that influence the choice for train stations of travelers that get from their departure point to a train station by bike. There are several methods to measure choices using different types of data. *Ranking* alternatives –what is done in sub question 2- provides information about the relative importance of attributes that influence station choice. This however doesn't say a thing about the size of the influence. *Rating* could be a way to derive the size of the influence. The disadvantage however is that rating is not something that is done often in real life. Besides that, it doesn't show the interrelation. The third option is a *choice*: the benefit of going for a choice experiment compared to ranking or rating is that making (unconscious) choices is a human habit (Molin, 2014). This strengthens the construct validity (Bryman, 2008). In a choice experiment the utilities are generated for certain influencing factors.

The type of data is also an important factor in a research design. In the case of a choice experiment the two options are revealed preference and stated preference. Revealed preference has the benefit that it has the highest familiarity for respondents since it is based on real choices. For example: 'what station did you pick when travelling to work?' The disadvantage is that everyone has different travel patterns, therefore it is much harder to exclude the factors that are part of the research from all other influences. This would lead to high standard errors and would therefore have a negative impact on the internal validity (Molin, 2014). Stated preference data has the advantage that a choice situation can be build up in the optimal way for the attributes researched. Every respondent makes his or her choices based on the same situation. The disadvantage is that people have to empathize in a situation that they haven't experienced in reality (Molin, 2014). This risk however can be reduced by designing the experiment in such a way that choice situations are as realistic as possible.

To answer sub question three a stated choice experiment is used. The stated data ensures that strong conclusions can be drawn about the influencing factors only. Using a choice experiment has the best performance on ecological validity because outcomes are based on a real life habit and conclusions will therefore be more realistic than with other methods

(Bryman, 2008). The goal is to find respondents at train station parking's and ask them to fill in an online survey. Direct surveying makes it easier to get response, however this limits the time a respondent is willing to take (e.g. because of catching a train). To increase the number of respondents the survey was also published through internet and social media.

1.3.3.2 Policy research and design (stage 2)

The second stage is the policy part. The goal is to discover and generate possible measures that influence the strongest station choice factors. Since influencing station choice is an innovative measure there are no turnkey solutions. What is available is knowledge about influencing behavior in the mobility field. Therefore, this stage starts with some background on influencing behavior. To find background literature and articles, scopus and snowball sampling are used.

Sub question 4 – What are possible measures to influence the factors and what are their pros and cons: Sub question four is answered by conducting interviews followed by a content analysis. The interviews have an explorative character, have a semi-structured set up (Bryman, 2008) and are mainly used to get new insights and measures. The outcomes of the choice experiment are presented to respondents, they are asked how this knowledge can be used to influence station choice. They are challenged to come up with concrete measures. They are also asked to come up with the pros and cons of those measures to get a complete view. At the end the measures are rated to test them for impact and effort to implement. Rating is executed by the author because of time limits of this study.

Sub question 5 – What would an implementation (in reality) look like: Answering sub question 5 has the goal to illustrate the potential of measures in real world case. How might a traveler change his behavior when certain measures are implemented? In the interviews to answer sub question four, some interesting locations were used as an example. This lead to the case Amsterdam Rai/Amsterdam Zuid. The impact of measures will be shown by monetizing all factors that influence the attractiveness of both stations.

1.3.4 Overview

The following scheme (Figure 5) gives an overview of the methodological steps taken in this project:

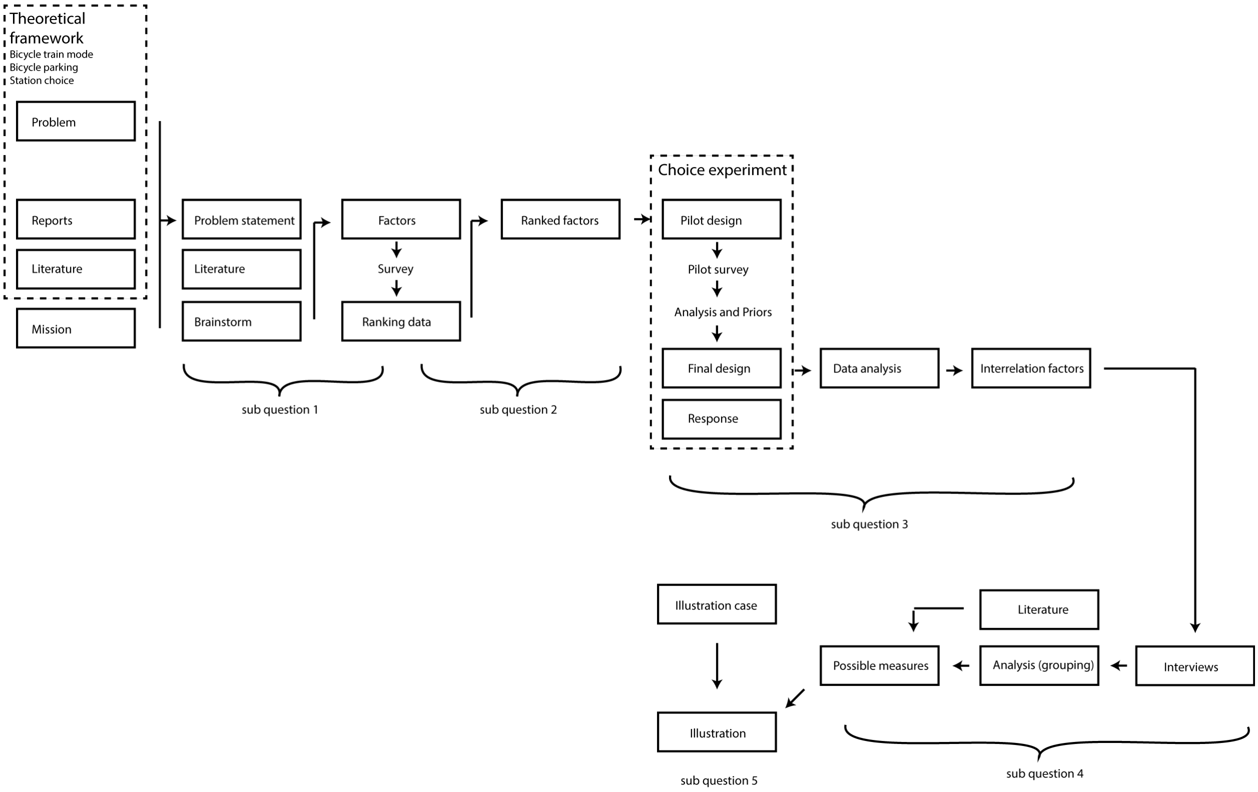


Figure 5 - Methodological steps

1.4 Added value to science and practice

1.4.1 Value for science

Previous research focused on access and egress modes of public transport journeys, but mode choice plays a larger role in there than station choice (Givoni & Rietveld, 2007). Extensive research has been done towards trade-offs in time and costs of travelling. However, those studies are often focused on car trips (Krabbenborg, 2015). The bicycle is getting more attention in research, not only for its benefits as a mode itself (Heinen, van Wee, & Maat, 2010) but also as an import part of a multimodal trip (Krizek & Stonebreaker, 2010) (Pucher & Buehler, 2009). When looking at the bicycle and train combined in one as the bicycle-train mode, research is still in its infancy. With this in mind, there are a lot of knowledge gaps in several disciplines and different parts of the modality (Kager, Bertolini, & te Brömmelstroet, 2016). Studying the bicycle-train mode from a behavioral point of view will not only be interesting for the bicycle-train topic but also for the knowledge about cycling in general. Cycling remains a hot (research) topic.

1.4.2 Value for practice

This research originates from a problem that occurs in reality; parking pressure at stations (Trouw, 2014). Contributing to the knowledge about choice behavior of bicycle-train travelers may help to solve this problem. The philosophy is: keeping the parking at large stations usable by convincing some of the users to opt for another station. Ultimately this may lead to savings that could be invested in other aspects of mobility. A euro can only be spent once. ProRail and lots of municipalities could use insights in station choice behavior of travelers. Especially the larger stations in the Netherlands suffer from overcrowding problems (Van Boggelen, 2008). Outcomes of this research can help decision-makers in coping with bicycle parking problems at railway station. It gives them a larger set of tools to keep the bicycle-train mode and public space attractive.

1.5 Commissioner

Ministry of Infrastructure and the Environment

The ministry of Infrastructure and the Environment is responsible for infrastructure, spatial planning and environment on a national level. It is subdivided in several directorates which are responsible for different subjects. The "dictoraat generaal bereikbaarheid" (DGB, directorate general accessibility) is responsible for most of the national transport infrastructure on land. DGB itself contains several departments, one of them is "OV en Spoor" (OVS, Public Transport and Rail). OVS is the client for this research assignment. As mentioned before congestion problems occur at crossings and at parking spots. Crossings and parking's are a local affair, however parking spots at station link with the national rail network. Therefore, the ministry has a shared responsibility for this. The need for this assignment originates from the current problems considering bicycle parking at railway stations.

2 Exploring factors that influence station choice

Travelers base their station choice on different factors. For some the distance and the trip towards the station might be most important, whilst for others the station itself (e.g. services and number of connections) is what matters most. This chapter explores all the factors that play a role in the choice for a station. First the methodological approach is discussed, followed by the factors that are based on literature. This is followed by a section that incorporates extra factors that users mentioned as influential. Within those sections a subdivision is made based on the trip parts: bicycle part, transfer part and train part. At the end an overview of the factors is shown.

2.1 Methodology

Since not much research is done to station choice, and even less for station choice combined with bicycle access it is highly probable that not all factors can be found and supported by literature. Therefore, the search for influencing factors is fulfilled in several stages. This study starts with a literature study. It is assumed that this will mainly lead to the more obvious but also strongest factors. After the literature study talks are held to discover the factors that aren't found in a literature study.

Literature is collected with the help of the index tool 'scopus'. The search for literature started with certain combinations of the keywords: bicycle, bike, train, station and choice. When some relevant literature was found snowball sampling (Bryman, 2008) proved itself to be a valuable way to find other literature. Also, google scholar was used since a broad variety of articles is available there.

The input for the exploration phase came from colleagues from the ministry and the university supervisors of this study (6 in total). They were asked on what they base their choice for a certain departure station. Not from their professional expertise but from their experience as a cyclist. The reason for this approach is mainly based on efficiency. They were easy to approach, which matched the time frame of this explorative phase. Because of their experience as travelers they came up with valuable insights.

When focusing at the composition of an access trip, the access part consists of the road towards the station and a part of the transfer. Therefore, a subdivision of influencing factors can be made: access factors for the **bicycle part**, station characteristics for the **transfer part** and train service characteristics for the **train part**. Sometimes those different factors occur together in literature. This chapter is mainly in order of the three trip parts, however sometimes overlap can be observed.

2.2 Literature

2.2.1 The access part

Literature that focuses on station choice is relatively scarce. However, some processes that are linked to station choice, like factors that are part of the generalized transport costs can give insight in factors that are important for people. The concept of generalized (i.e. converting non-monetary aspects to monetary value) transport costs is a method that is widely used in research (Mcintosh & Quarmby, 1972). La Paix Puello & Geurs (2016) tried to generalize the costs of cycling to railway stations. Several factors can be linked to station choice. The first one are the cost that don't have to be generalized: **the out of pocket costs.**

One of the most important parts of the generalized transport costs are the **costs of time**. When linking this to the access this would be the travel time.

Krabbenborg (2015) wrote a thesis about the appreciation of different factors when cycling towards stations. This thesis gives valuable insights that can be used in answering a part of this sub-question. The next paragraph gives an overview of the ‘soft’ factors found in that thesis. Only the factors that are assumed to have influence on station choice are mentioned, not the factors influencing mode choice.

Directness and the **right of way** do have a partial influence on the access travel time, but they also have influence on the ‘experience’ of the trip (Stinson & Bath, 2004). Another factor is **social safety** which is influenced itself by several factors. The **presence of lightning** on the road towards a station has a positive influence on the social safety of a trip towards a station (La Paxi Puello & Geurs, 2016). The landscape of the route is also of influence, while a flat and green landscape is welcomed by cyclists the appearance of trees (**vegetation**) can be of negative influence due to the blinds spots it creates (Wahlgren, 2011). Not only the social safety is of influence but also the traffic safety. This is often associated with **design of infrastructure** and the **number of other users** (La Paxi Puello & Geurs, 2016)**. Separated bike lines** are often valued positive. **Obstacles** and **parked cars** are of negative influence. besides (Garcia, Gomez, Llorca, & Angel-Domenech, 2015).

2.2.2 The station itself

The other aspect that is assumed to be of influence are the characteristics of the station itself. Here again a division can be made. On one hand the characteristics that are mainly focused on the station itself and on the other hand the characteristics that are linked to the train service.

Out of pocket costs at the station are the costs of parking a bicycle for a certain amount of time (**parking price**). The costs of time spent at a station would be associated to the time spent for walking between the parking and platform. This is assumed to be the most important aspect of **transfer time** since waiting time doesn’t have to be of influence. The bicycle is a continuous mode instead of an interval mode, therefore it is possible reduce waiting time to almost zero. A factor that has both influence to time spent at the station as on the perceived quality of the transfer would be **the chance of finding a parking spot**. A small chance would result in a long searching time and a frustrated traveler. This searching time could be seen as a form of unavoidable waiting time. Since waiting time is perceived more negatively than travel time (Algers, Hansen, & Tegner, 1975) this would be of negative influence.

2.2.3 Link with rail system

When focusing on the part of the station that serves the rail network, it is important to look at what people would prefer as a traveler. In general travelers, don’t like to have a transfer in their trip. This is measured by the degree of **directness** (Zhao & Ubaka, 2004). A trip is direct when a traveler doesn´t need to transfer. Another factor is the **frequency** of the train service. A high frequency means a low average waiting time (Bowman & Turnquist, 1981). Besides that, there are more travel options per hour, which will make it possible minimize the lost time between real arrival time and desired arrival time. The next factor is **reliability** of service, this service characteristic has a link with frequency (Bowman & Turnquist, 1981). When there is a low frequency it is more important to have a reliable service since the impact of a disruption is less with a high frequency. The degree of reliability is not only linked to train travel time but also has influence on the experience of the user.

2.3 Exploration

The exploration phase based on the input of cyclists resulted in a lot of factors that again can be subdivided over the trip parts. In general, it consists of the less obvious and second order influences. It remains important to get the most complete overview, as some of the factors can´t be subdivided and are linked to the entire trip those factors will be discussed first. Note that only the factors that were not already revealed in the literary review are mentioned.

2.3.1 General factors

Not all factors are linked to the trip parts. **Trip purpose** is an important one. Someone travelling to and from work might have other preferences than a recreational traveler. An example would be that a recreational trip is most of the time incidental, therefore route knowledge is lower and this may lead to a higher chance of a traveler choosing the closest station. The **total trip length** is not only directly of influence on the station choice (sum of separate trip lengths), but might also be of influence on the appreciation of influencing factors.

Personal characteristics might also lead to differences in station choice. This is not necessarily a direct link between the two, but different characteristics might lead to different appreciation of influencing factors. Those three mentioned general factors can be identified as context variables.

2.3.2 The access part

The access mode in this research is the bicycle, this is an active mode that sometimes has to undergo the influence of the **weather**. A rainy day might have an influence on the maximum acceptable access trip length.

In literature it was found that the length of the access trip could be of influence on the station choice. However, this factor might be influenced itself by the relative travel time of this access trip compared to the total travel time. For longer trips, someone is willing to accept a longer access time.

2.3.3 The station itself

The quality of the parking equipment is a factor that may influence the station choice. This reveals itself in several forms. For example: the **level of maintenance**, or the **physical size** of the equipment. Some non-standard bicycles cannot be placed in any parking. Also the level of theft prevention might play a role, a factor that will gain influence with the upcoming of the electrical bicycle. Another factor that gets a role with the upcoming of this type of bicycle is the **presence of charging points**. What also could be of influence are the **shelter** and **space** in the station.

2.3.4 Link with Rail system

In the Netherlands a station in general is being serviced by two types of trains: intercity and sprinter. Stations that have an **intercity status**, which means that all domestic trains stop, have more direct connections. For some of the travelers intercity stations will therefore be preferred. This has a strong link with directness.

2.4 Dependency of factors

Not all influencing factors stand alone, most of them are part of an 'umbrella factor'. The best way to show the links is to visualize them in a tree. The result is shown in Figure 6. The dashed outline represents the external variables that influence the factors (context variables and personal characteristics). The argumentation for the setup of this factor tree is shown in Appendix A.

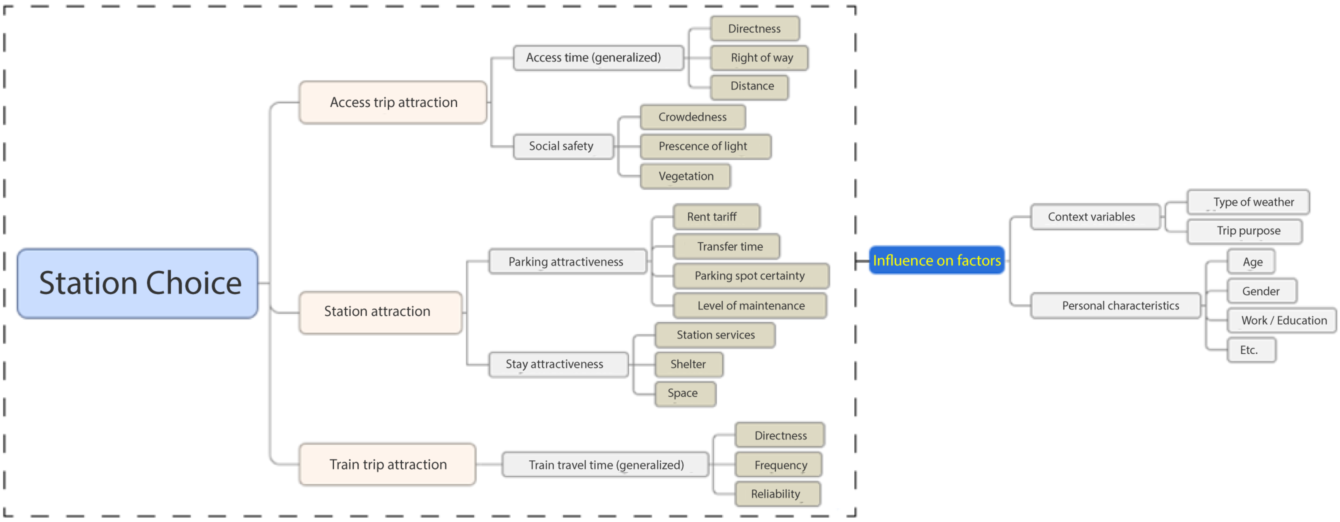


Figure 6 – Factors that influence station choice

2.5 Conclusion

Station choice is influenced by several factors. The strength of those factors doesn't play a role in this chapter, as the goal was to identify all relevant factors influencing station choice. Several methods were used to acquire the factors. First literature was reviewed. Because not much literature about station choice is available the factors were derived from broader transport literature. Since this derivation doesn't give a complete picture about the factors this phase was extended with an exploration.

A division can be made between the different aspects of station choice: the access part, the station itself and the rail part. All those parts have their own factors that make a station attractive or not. For the access trip, the parts of the generalized access time play a role as does social safety. For the station characteristics, the derivatives of parking attractiveness play a role as do the factors that influence the attractiveness of the stay. For the train part the derived factors of generalized travel time play a role in station choice. All those factors influence station choice directly or at least through an umbrella factor. There are however also external factors that influence the strength of the direct factors in the station choice process. Those so-called context variables are type of weather and travel purpose. Also, the personal characteristics can be of impact on the valuation of the factors.

3 Ranking the factors that influence station choice

When choosing a station to cycle to, not all factors are of the same importance. Travelers tend to weight some aspects heavier than others. This chapter provides insights in the relative importance of the factors found in chapter 2. This is done in several stages. First the methods are explained, then the factors will be made measurable and understandable for respondents, after that a large ranking is made with a low number of respondents, followed by a top 7 ranking by a higher number of respondents. The chapter ends with a comparison with the theory of satisfiers and dissatisfiers and concluding remarks.

3.1 Methodology

The factors found in chapter 2 are used as input. To find the relative importance in station choice behavior the factors are ranked on their relative importance. In the first phase the factors are made respondent proof. This means that the factors should be imaginable and that overlap between the factors has to be minimal. The overview of factors shown in the previous chapter helps with minimizing the overlap, where the conceivability is a simple check with minor adaptations. The context variables are left out of this research because context variables cannot be ranked with direct variables since they influence each other. The aim is however to find the effects of the context variables and personal characteristics in the choice experiment of this research project.

Second, seventeen of the found factors will be ranked by respondents. This is done on the basis of a manual card ranking. A respondent is presented a set of cards which he or she has to put in the order of importance. This method was executed on 3 respondents. Those respondents are working at the ministry and all have familiarity with the subject as travelers. The main reason to ask those particular respondents was because it was efficient to use colleagues for this. There was critique from the respondents that 17 cards where to many compare everything, especially the less important ones. An extra phase was introduced. In this phase 20 respondents gave their top 7 out of the 17 possible factors. As respondents family, colleagues and friends are used, mainly because they could be reached in an efficient way. They have different backgrounds and different habits but are all familiar with cycling to the station. In the questionnaire that was brought to attention through email respondents were specifically ask to only fill in the questionnaire when they had experience with cycling towards a station. Familiarity will strengthen the research validity (Bryman, 2008). Seven out of seventeen is based on research that most humans can keep only seven things in mind at the same time (Miller, 1956). To analyze the data acquired with this ranking a simple scoring method is used where the highest factor in the top 7 gets seven points and the lowest 1 point (Thomas & Kiwanga, 1993). This analysis is widely used in practice, for example in popular survey services (SurveyMonkey, 2017)

3.2 Making the data respondent proof

In this step the found factors are checked on several aspects to make them usable in a ranking experiment. Some are combined due to the high number of factors, others are split because of overlap and most are changed because of conceivability. Since the questionnaire will be in Dutch the factors are translated to Dutch. The results are shown in Table 3. The order of the influencing factors is the same as in the exploration phase. Colors indicate the three different backgrounds of the factors.

Table 3 - Conversion table of factors

Factors	Reduction	Overlap	Imaginable	Included in ranking
Directness	Route quality	-	Logical route	Logical Route
Obstacles	Route quality			
Right of Way	-	-	-	Right of Way
Distance	-	-	Cycle time	Cycle time
Crowdedness	-	-	-	Crowdedness on route
Presence of light	Social safety	Social safety to station	Feeling safe towards station	Feeling safe towards station
Vegetation	Social safety			
		Social safety on station	Feeling save at station	Feeling save at station
Parking tariff	-	-	-	Parking tariff
Transfer time	-	-	Parking to platform time	Parking to platform time
Parking spot certainty	-	-	-	Parking spot certainty
Level of maintenance	-	-	-	Level of maintenance
Station services	-	-	Station services (restaurants, shops)	Station service
Shelter	-	-	-	Sheltered station
Spacious	-	-	-	Spacious station
Directness	-	-	Direct trip (no transfer)	No transfer in train trip
Frequency	-	-	-	Frequency
Reliability	-	-	-	Reliability
Total travel time	-	-	-	Total travel time

3.3 Ranking all factors

To place the different factors in order, a set of cards was presented to respondents. The aim of this research was explained and the respondents were asked to rank the card with a hypothetical question in mind: *if you had to make a station choice when cycling towards a station, which factors would be most influential on the choice, and what factors would be least influential?* This phase was meant to be the only ranking. However, feedback was given that this method was not optimal due to the high number of factors. Therefore, it was decided to stop this experiment and add an extra round where only the most important factors had to be ranked. Despite the second ranking was stronger, the broad ranking still gave information about the importance of the factors. Based on the five respondents the rankings is as follows:

1. Total travel time (bike + transfer + train)
2. Direct trip (no transfer)
3. Transfer time (between parking and platform)
4. Costs of bicycle parking
5. Chance of finding a spot in station
6. Reliability train service
7. Bicycle travel time
8. Frequency train service
9. Right of way
10. Logical bicycle route
11. Crowdedness on route towards station
12. Social safety on route
13. Station services
14. Social safety on station
15. Shelter
16. Spacious station
17. Maintenance of station parking

The deviation from this average outcome is marginal. All factors were within three positions from the average presented in the list above. The results will be compared with the outcomes of the next phase in the next section.

3.4 Final ranking

In this phase a ranking survey was completed by 20 respondents. They picked a top 7 out of the seventeen factors available. They were asked to compose a top 7 with a hypothetical question in mind: *if you had to make a station choice when cycling towards a station, which factors would be most influential on the choice, and what factors would be least influential?* In the analysis of the data, to get an overall ranking, all factors received a score (7 points for number one, etc. 1 point for number 7). The factor with the highest score is assumed to be most influential, etc. etc. The outcomes of this phase are as follows:

1. Total travel time (bike + transfer + train)
2. Direct trip (no transfer)
3. Bicycle travel time
4. Costs of bicycle parking
5. Frequency of train service
6. Chance of finding a spot in station
7. Reliability of train service
8. Transfer time (between parking and platform)
9. Shelter
10. Crowdedness on route to station
11. Social safety on station
12. Social safety on route
13. Station services
14. Logical bicycle route
15. Right of way
16. Maintenance of station parking
17. Spacious station

The mean absolute deviation of the first seven factors is 1.5, which means that on average the answers of respondents deviate one and a half position from the list shown above. Because only a top 7 was given the deviation of the lower position factors is not accurate enough. This means it automatically has an extremely high deviation when an on average low factor is mentioned in the top 7 because it is not compensated by sub 7 mentions in the response. The deviation of 1.5 shows that respondents are on average quite consentient.

In this ranking survey, respondents also had the possibility to give feedback on the questionnaire and definitions. Some respondents mentioned the overlap between 'chance of finding a spot' and the 'transfer time'. In other words: it is always possible to find a spot, but not always in an acceptable amount of time. Combining the two would lead to a 3rd place, this is not fair because some respondent mentioned both in their response. When compensating for that effect by removing the 2nd response this combined factor would still hold a 4th place. This new order is set and would lead to a new top 7. Only a new top 7 is presented since there are no changes in the sub-top:

1. Total travel time (bike + transfer + train)
2. Direct trip (no transfer)
3. Bicycle travel time
4. Parking to platform time
5. Costs of bicycle parking
6. Frequency
7. Reliability

It is made clear that the total travel time is the most important aspect. Of course, the travel time consists of all the separate travel times. Not all those travel time components have the same impact. That bicycle travel time holds a third place shows that this is of importance itself. A reason for this could be that cycling costs more effort than transferring. The second position is for the directness of the trip. In general, people don't like transfers, therefore a direct train connection is appreciated. The fourth position is held by the previously mentioned combination of finding a parking spot / parking to platform time, this shows that for travelers it is of importance to find a parking spot that is not too far away from a platform. On the fifth place are the costs for the traveler of bicycle parking. This shows that people are influenced by the tariff when making a station choice.

Comparing both methods, the outcomes, especially in the top of the list, are approximately the same. Only bicycle travel time is of less importance. This still holds a 6th position when executing the same correction as in the last ranking. However, since the number of respondents in the last ranking is higher, the first ranking should be mainly used as supportive for the last one. In this case the outcomes of the first ranking do support the outcomes of the last, therefore the outcomes of the last phase are used further in this research project.

When putting the outcomes in perspective of the three categories from the previous chapter (access part, Station itself and Link with rail) it becomes clear that for each category the most important factor is a component of travel time. Train travel time was not a separate factor but is already a part of total travel time. It can be isolated with knowledge about access time and transfer time which are also mentioned in the top-list. When looking to the other top-factors they are from the latter two categories. Costs of the parking are part of the station characteristics and directness (no transfer), frequency and reliability are variables of the rail network.

3.4.1 Satisfiers and dissatisfiers

The order in station choice factors shows that some are more important than others. This means that in general lower order factors will only play a role when the higher order factors are fulfilled. When this is translated to station choice, the higher factors are fulfilled when the factors are equal between stations for a specific journey. The difference of importance in factors is a common thing in mode choice. The distinction commonly made is the one between satisfiers and dissatisfiers. Van Hagen, Peek & Kieft (2000) created a Maslov pyramid with satisfiers and dissatisfiers for the door to door journey. Since the station choice is a relevant part for the door to door journey this principle can be applied to the order of station factors found in this chapter. Dissatisfiers are always stronger than satisfiers, dissatisfiers push people to the other option, while satisfiers can only pull people towards the option if there are no dissatisfiers.

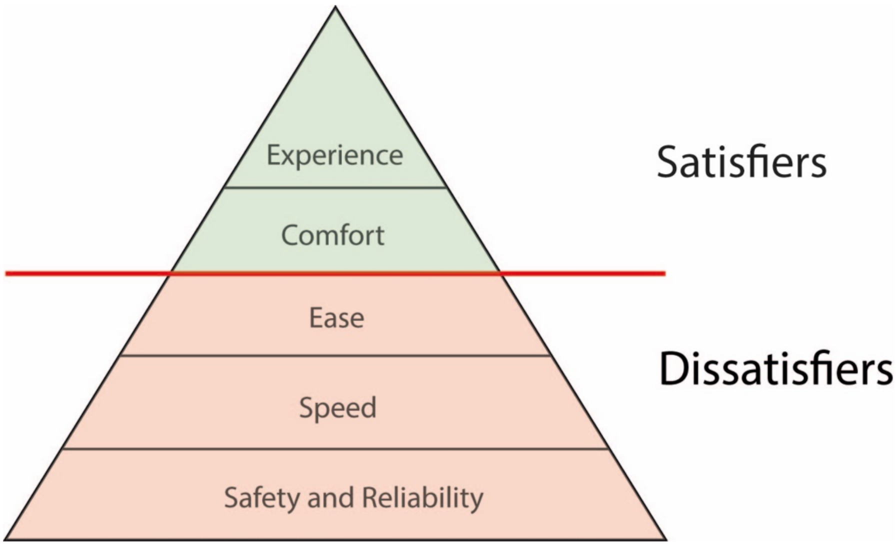


Figure 7 –Pyramid of satisfiers and dissatisfiers (Van Hagen, Peek & Kieft, 2000)

The base of the pyramid is formed by safety and reliability, then the second layer consist of speed, followed by the layer ease. After those three layers of dissatisfiers the comfort and experience layer form the top of the pyramid as satisfiers. When comparing this pyramid with the outcomes of the ranking most of the factors can be matched. Safety and Reliability are exceptions, they are strongest in the pyramid, but have less influence according to the ranking. The reason for this might be that safety in the pyramid is not only social safety but also physical safety. Safety levels in the Dutch railway system are high regardless of the station, therefore this is less important in station choice. When looking at the reliability of the train system not much difference between stations is expected since the stations are linked with each other by the same railway network. Since only differences between stations can impact station choice safety and reliability don't have the same spot in the pyramid as in the ranking.

3.4.2 Conclusion

This chapter focused on answering sub-question 2. In several steps the most influential factors of station choice were indicated. Data was acquired from a relatively small number of respondents but still the outcomes are valuable. Total travel time is the most important factor, but also the separate time factors hold a high position. This research part also shows that people are influenced by price in their station choice and that not only travel time is of influence but also the directness of the train journey. Frequency and Reliability of the train service are of less importance but are still a factor in station choice. Station services, maintenance and social safety are only of marginal influence. Applying the approach of the pyramid of needs to the ranking gave extra insight in the difference between factors. Some are satisfiers and others are dissatisfiers. The dissatisfiers are always stronger than the satisfiers.

4 Relations between factors, creating the choice experiment

This chapter discusses the design of the choice experiment in two steps. First a pilot study is set up. This includes a pilot experiment and the creation of a survey. This created survey is directly used in the pilot and forms the basis of the survey for the main experiment. After this the outcomes of the pilot study are assessed. At the end those outcomes are used to set up the final experiment.

4.1 The pilot study

A pilot study was executed to obtain parameters and test for understandability. The parameters can be used to create an efficient choice design for the main experiment. And the information about understandability helps to create a better survey for the final experiment. This section explains the creation of the experiment for the pilot study.

4.1.1 Design of pilot study

The number of factors that can be included in a choice experiment is limited. The more factors (or in choice modeling: attributes) are used, the more choice situations must be presented to respondents to get valuable results. Since the number of choice situations is limited the number of factors also is. Not only the number of attributes is of influence, also the level of attributes is of influence (Molin, 2014). One value of an attribute represents one level. For binominal attributes the level is automatically two, however when non-linear effects are expected a minimum level of three is required (Molin, 2014). Besides the non-linearity, presenting more than two realistic options to respondents can also be a reason to choose for more attribute levels. Higher levels than three are also possible and could provide more insights, this would also increase the number of choice situations. In this research, it would be more valuable to increase the number of attributes than to increase the attribute levels.

Based on the answers to sub-question two it would be most logical to use the top of that list. When looking at that list the top is formed by:

- Total travel time (bike + transfer + train)
- Direct trip (no transfer)
- Bicycle travel time
- Parking to platform time
- Costs of bicycle parking
- Frequency
- Reliability

It is not possible to use this top 7 factors right away because of several reasons. First there is overlap between the factors, secondly the required attribute level is not determined yet and third, the number of attributes would probably be too high for the choice experiment

The overlap reveals itself in the top of this list, total travel time already has the components bicycle travel time and parking to platform time in it. Since the list itself shows that bicycle travel time and transfer time are valued differently, it would be most useful to include all factors separately in the choice model. Changing total travel time into train travel time would have two results, first all travel times are included separately and second total travel time is automatically included since all time parts are included.

The next step is to determine the required attribute levels. For values of time and money non-linear effects are probable, therefore three levels are required. Taking this into account the following factors would have the next number of levels:

2 Levels: Direct trip, Frequency
3 Levels: Train travel time, Bicycle travel time, Parking to platform time, Parking costs

The number of maximum choice situations can be a bit higher for the choice pilot than for the final choice survey, since it is only a test. The possible number of attributes is found by trial and error. The software package Ngene is used to create an orthogonal design. An orthogonal design doesn't include all choice situations –as in a full factorial design- since there would be way to many, but is using a random fraction (ChoiceMetrics, 2014). For the pilot, therefore a fractional factorial design is used.

Including the top five would lead to 3*3*3*3*2 = 162 choice situations for a full factorial design. Ngene can create a fractional factorial orthogonal design with 18 choice sets. This is a high but acceptable number of choice sets. Including the top six would lead to 3*3*3*3*2*2 = 324 choice situations for a full factorial design. A fractional factorial orthogonal design with 6 attributes would require 36 choice sets. This is considered too high, even for a pilot. Taking this into account it would be best to include the following attributes in the pilot study:

- Direct trip
- Bicycle travel time
- Parking to platform time
- Train travel time
- Parking costs

4.1.2 Attribute level values

The attribute level values are supposed to be as realistic as possible. Furthermore, the intermediate distance between the values should be the same per attribute. In this case an average value is assumed with a +- addition. The intermediate distance for train travel time is based on extreme but realistic possibilities (e.g. Diemen Zuid- Utrecht Centraal, 2017). For transfers in the train trip there are just two options, 0 and 1 transfers.

Table 4 - Attribute levels

Attribute	Average value	Attribute level values	Source
Bicycle travel time	10 min	5, 10, 15	(Keijer & Rietveld, 2000)
Parking to platform time	3 min	1, 3, 5	Observations
Train travel time	35 min (real 38 min)	25, 35, 45	(Treinreiziger.nl, n.d.) + same interval as bicycle travel time
Parking costs	€0.50	0.0, 0.5, 1.0	(NS, 2016) Based on NS month subscription

By bringing all settings together Ngene can create a fractional factorial orthogonal design. The syntax is shown in appendix B.

4.2 Design of the survey

The pilot study is used to obtain parameters, but it also creates the opportunity to test other questions and the understandability of the pilot itself. The purpose is that the survey is the same in the pilot as in the final experiment. In this section the creation of the survey is put apart step by step.

One part of the survey consists of a choice set. The other part is formed by questions to obtain personal characteristics and habits. This information can be used to study their impact on the outcomes. The last part exists of extra questions that are used to obtain extra behavioral information about bicycle parking.

4.2.1 Part 1 – personal characteristics

The survey starts with a part about personal characteristics. The characteristics shown in Table 5 are based on the most important characteristics that the statistical bureau of the Netherlands (CBS) uses in their surveys. CBS doesn't use the same categorization for every survey. Here the one from the 'bevolkingstrends' research is used.

Table 5 – Personal characteristics and habits that are included in the survey.

Characteristics:	Answer options:
Age	<15 15-24 25-44 45-64 >65
Gender	Male, Female
Highest education	Primary School VMBO/MAVO HAVO VWO MBO HBO Bachelor University Master University PhD Other…
Household composition	Single-household (also dormitory) Two-person household Family with one or more children living at home One parent family with one or more children living at home Other…
Household income (Gross)	No income <10000 euro 10000 – 20000 euro 20000 – 30000 euro 30000 – 40000 euro 40000 – 50000 euro > 50000 euro
Labor situation	Student Employed (25 hours per week or more) Employed (less then 25 hour per week) Unemployed, looking for a job Unemployed, not looking for a job

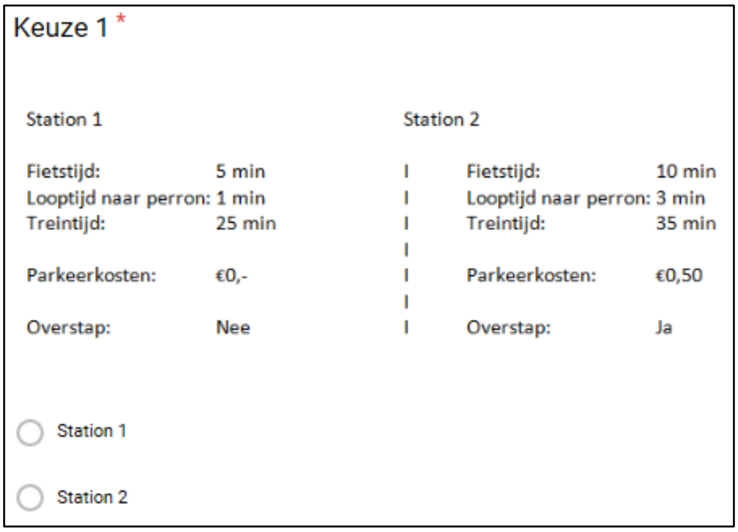
	Retired Incapacitated
ZIP code	1234 XX
Habits:	
Trip goal	Mainly School/Study/Work Mainly recreational Both evenly
Mostly used access mode	Bike Car Walking Public transport Other…

4.2.2 Part 2 – choice experiment

The second part is formed by the orthogonal design that was created by Ngene. The design consists of 18 different combinations of two alternatives for the pilot study and 9 for the final survey. The alternatives itself vary in attributes. The first rows of this design are shown below:

Situation	alt1.a	alt1.b	alt1.c	alt1.d	alt1.e	alt2.a	alt2.b	alt2.c	alt2.d	alt2.e
1	5	25	1	0	0	10	35	3	0.5	1
2	10	35	3	0.5	0	15	45	5	1	1
3	….									

This design is then transformed into a presentable choice situation (Figure 8). Respondents were introduced with an explanation of the methodology and a context that they had to imagine.


Keuze 1 *

Station 1			Station 2	
Fietstijd:	5 min	I	Fietstijd:	10 min
Looptijd naar perron:	1 min	I	Looptijd naar perron:	3 min
Treintijd:	25 min	I	Treintijd:	35 min
Parkeerkosten:	€0,-	I	Parkeerkosten:	€0,50
Overstap:	Nee	I	Overstap:	Ja

Station 1

Station 2

Figure 8 - Example of a presented choice situation

4.2.3 Part 3 – extra questions

The last part consists of extra questions, those questions had different purposes. The purpose is put apart per question:

Information: In the previous choice set there was information available. What would you do if this information would not be available:
- Choose the station that feels the closest
- Lookup information
- Other …

This question was added due to the interest of the ministry in the influence of information. Since one of the aspects of a choice set is that there is information available (to base the choice on) this could not be combined with the choice experiment. Therefore, a separate question was added.

Separate time factors: The choices consisted of three time factors, did you mainly value the time total or have you valued them separately?
- Total
- Separate

In the choice pilot three different time factors were included in each alternative. They represent different parts of the trip. However, because they are shown below each other there is the risk that respondents add them up and just compare the totals. This might lead to different choices. This question is to check the effect of the three time factors per alternative.

Feedback: The outcomes of this questionnaire form the building blocks for a second questionnaire. Feedback is therefore highly appreciated. In the text field below you can leave your comments.
- Text field ….

This question was added to acquire feedback. This feedback can be used to optimize the final survey.

4.3 Results of the pilot

The pilot survey was filled in by 43 persons, all answers where usable, this means that the choice pilot had a response of 43. The group of respondents mainly consisted of colleagues since the questionnaire was sent out to the department. Therefore, the outcomes are only representative for this type of travelers. This however is not a problem for a choice pilot since it is used to retrieve feedback and exclude dominant alternatives (Molin, 2014). Still it is valuable to indicate what the characteristics of the respondents are, they can be found in appendix B.

The outcomes of the choice pilot are statistically analyzed by the open source software package Biogeme. This Bison based software is widely used for discrete choice analysis. Biogeme requires a syntax as 'command' and a data file as input. The software uses the multi nominal logit (MNL) model. This type of model calculates the parameter values by finding the maximum utility of a utility function. In this case the utility function is:

$ALTi = \beta_{biketime} * Biketime_i + \beta_{transfertime} * Transfertime_i + \beta_{traintime} * traintime_i + \beta_{price} * Price_i + \beta_{direct} * Transfer_i$

This utility function is incorporated in a Biogeme syntax, this syntax can be found in appendix B. The outcomes of the analysis are shown in Table 6.

Table 6 - Parameter estimates choice pilot

Name	Value	p-value
Beta bike time	-0.124	0.00
Beta transfer time (btw. trains)	-0.732	0.00
Beta price	-1.32	0.00
Beta train time	-0.103	0.00
Beta time to park (platform-train)	-0.102	0.00

The parameters are of the expected sign. They are all negative, this means for example that more travel time makes a station less attractive. Furthermore, the P-value which indicates significance shows that all parameters are significant at the 1% level. This shows that the parameters are suitable priors for the creation of the final experiment.

4.3.1 Feedback

The pilot survey was also used to obtain feedback. A feedback text field was part of the survey, besides that some emails were received with more elaborate feedback. The feedback was categorized in 'vagueness' and 'methodology and question specific'. Table 7 contains this categorization, the specific problem and a solution for that problem. The solutions are used in the development of the final survey.

Table 7 - Feedback overview

Theme	Sub-theme	Problem	Solution
Vagueness	Purpose	To some respondents it was unclear why they had to choose between two situations and what it was used for.	Clarify
	Instructions	Unclear whether choices are real or should be imagined (best in that situation)	Clarify
Methodology and question specific	Personal characteristics	Unclear whether income is net or gross	Clarify
		Options: don't know, don't want to give are not available	Make available by specific questions. E.g. income
		No distinction between students and workers	Make a distinction in trip purpose between school/study and work.
	Choice set	Some alternatives have an obvious choice (dominant alternatives)	Purpose of pilot study is to remove dominant alternatives. Not a problem in the final survey.
		Not all factors where included	No solution, this methodology has a maximum number of attributes.
		Too many sets	Final survey is shorter
		Time factors are not always separately judged	Don't categorize by type (time, price, directness) but by trip part (access, transfer, egress) this will make it less easy to just add up the factors.
	Extra questions	Questions sometimes have limited answering options	Adding option 'other…'
Other	Language	The texts are very intellectual and not suitable for every group in society.	Make texts more understandable
	Obligatory questions	Most questions were obligatory, this gave the questionnaire an unfriendly look.	Remove the obligation to answer. Cope with respondents that don't answer by removing them from the data.

4.4 Final survey and choice experiment

In this chapter the creation of the final choice experiment and the final survey is put apart. This is mainly based on the findings gained in the pilot study. First the choice experiment is discussed, followed by the adaptation of the survey. At the end the collection of data and the target group is being discussed.

4.4.1 Choice experiment

The choice experiment is one of the main aspects of this study. The strength of this study depends on a good execution of this experiment. The creation of the choice experiment consisted of multiple steps. The first step was to acquire priors by carrying out a pilot study. Here the priors are used to develop an efficient choice set. By making the choice set efficient the length of the choice set can be reduced with a minimal reduction of data quality. A short survey is essential for acquiring enough respondents.

4.4.2 Efficient design

When creating a choice set, multiple design options are possible. There is the full factorial design where all possible combinations appear. This design is only usable with a very small number of attributes and levels. More commonly used are the fractional factorial designs. Those designs only contain a fraction of the possible combinations (ChoiceMetrics, 2014). In the choice pilot a fractional factorial design was used in the form of an orthogonal design.

For the final choice experiment the number of choice situations is further reduced. The goal is to incorporate the best combinations within the minimum number of choices. This is what makes a design efficient. Efficient designs require priors to determine the optimal combinations. Here the number of choice situations is further reduced based on the acquired parameters of the choice pilot.

Where orthogonal designs only try to prevent correlations between attribute levels, efficient designs don't have a strict ban on correlation but try to maximize the information that is acquired per choice situation. In this way, a choice set is created that is very efficient considering parameter estimates. This is possible because of the extra information that the priors provide (Molin, 2014).

There are different types of efficient designs. The goal is always to reduce the inefficiency of the design, reducing this however can be done in multiple ways. Every type of design makes use of the asymptotic variance-covariance (AVC) matrix. This matrix is derived out of the estimated parameters (in this case the priors). It contains the variance of the parameters and the covariance between the parameters. How the efficiency measures make use of this matrix depends the type of efficient design. Three designs can be distinguished: A-efficient, D-efficient and S efficient.

Table 8 - Types of efficient designs (Molin, 2014)

Type of design	What it optimizes
A-efficient	Only looks at the variances, not at the covariance's. Worthy if variances have the largest impact.
D-efficient	Takes the determinant of the AVC matrix with the assumption that there is only one respondent.
S-efficient	Tries to reach significance for the parameter for which it is hardest to reach significance.

D-efficient designs are in general considered the strongest designs. For specific cases A-efficient and S-efficient designs are more suitable. For example, when the expected impact of parameters differs a lot it might be harder to reach significance S-efficient is useful solution, because it focuses on that weaker parameter (Molin, 2014). In this experiment, no specific problems are expected, therefore the commonly used D-efficient design will be used.

4.4.3 Choice situations:

Each respondent is presented a list of choice situations. The more choice situations, the more information is gathered. However, there is a backside to this. It can create fatigue for respondents because a lot of similar questions occur after each other. This might stop them from answering the questions about the choice set. It would be even worse if respondents don't answer the questions truthfully because they want to rush. It would lead to wrong parameter estimates.

The pilot study consisted of 18 choice rows. As expected respondents experienced this as too many. Considering the feedback that was acquired in the pilot study; about half the choice rows would be a more appropriate amount. However, not only the wishes of the respondents are important for the determination of the number of rows. In discrete choice modeling attribute level balance is an important aspect. An orthogonal design has attribute level balance by definition. This is not obligatory for efficient designs, but still preferred (Molin, 2014). The attribute levels are 2 and 3. To get attribute level balance the number of rows would have to be a multiple of 2 and 3. So 6, 12, 18… Six however would lead to less information, while twelve is considered a bit too many rows for a survey that is presented to respondents at a station. Nine is therefore the second-best option. It would give attribute level balance to 80% of the attributes. Therefore, nine is the optimal number of choice situations for this study.

The software package NGENE is used to create the choice set. By performing a lot of iterations, it can reduce the amount of inefficiency to a minimum. When the choice set is created NGNENE supplies several efficiency measures. The D-error is the amount of inefficiency that has to be minimized. The S estimate is the number of respondents needed if all respondents would answer likewise the pilot study.

Table 9 - Efficiency measures

Efficiency measure:	Value:
D error	0.068
S estimate	21.09

A D-error of 0.068 is considered rather low. It is much closer to zero than to one. Trial and error was used to check whether the D-error would differ a lot for a 6 or 12 row design. For a 6 row design the D error was a lot higher, while for a 12 row design the D error was just a little lower. The S-estimate indicates that a minimum of 22 respondents is needed to get significant outcomes (when the respondents show the same behavior as in the pilot).

4.4.4 Adaptations in survey design

The final survey is an improved version of the one used in the pilot study. Improvements are mainly based on the feedback that was given in the pilot study. One of the more important ways to improve understandability is to give an example how to answer the survey. Furthermore, less formal language will be used and some answering options are added. A copy of the survey can be found in appendix C.

The survey consists of three parts. First some questions about personal characteristics are presented. Followed by the nine choice situations. At the end of the survey several final questions are added to get insight in some contextual effects. The survey is build up in Google forms. Response is directly added to a spreadsheet where it is presented suitable for analyzation.

4.4.5 Data gathering and respondents

The respondent target group is 'train travelers that access the station by bike'. The reason to focus on cyclists is that this is a station choice project where the mode is a given. In this case, it is mainly interesting what the people would do that use the bike as an access modality. The most likely location to find those travelers is at a railway station. The problem however is that generally this goes hand in hand with a maximum amount of available time.

Two approaches are developed to cope with this problem. First people are asked personally with a flyer and a link to fill in the questionnaire online. The second approach is not to ask respondents after their access trip, but before their reverse access trip at the end of the day. In general, they will have more time available since they don't have to catch a train anymore.

Next to acquiring respondents at the station, they were also acquired online. The survey was distributed through social networks (Facebook and LinkedIn). The main reason to do this is to have a backup option, if acquisition at the station fails.

NGENE, the software that was used to create the choice set calculated that only 21 one respondents would be needed. This is however a theoretical number. This number is only valid if the same information is provided as where the priors are based upon. A doubling of respondents would be a safe amount to get significant results with other respondents. Significance is the only important measure. For generalization purposes, it is important to get many respondents. Here however limitations of this study occur. Because the available time for data gathering is limited an acceptable minimum would be 100 respondents.

To make it more easy for respondents to remember and find the survey website the domain name 'stationskeuze.nl' was claimed. This website redirects respondents to the survey program. This link is also printed on the flyers that are used to remember people to respond to the survey. The flyer is shown in Figure 9.

Figure 9 - Flyer used to acquire respondents

5 Relations between factors that influence station choice, the outcomes

This chapter discusses the outcomes of the choice experiment. First the result of the data acquisition is briefly described. This is followed by the estimation of the parameters. Then the results are explained and visualized and a subdivision is made on personal characteristics and habits. After that the outcomes are validated and at the end the generalizability is discussed.

5.1 Result of the data collection

Two methods for acquiring data from respondents were eventually used. This was done simultaneously. The first method was to ask travelers at stations (Amsterdam Zuid and Amsterdam RAI) to respond to the questionnaire. The other method was to publish the questionnaire online on social networks (Facebook and LinkedIn). In total about 150 people were approached at the station. However, only 21 people responded to this. This is not enough for an analysis, therefore the responses coming from the social network and email are important to get significant and stronger results. In total 269 respondents filled in the questionnaire.

5.2 Parameter estimation

5.2.1 Model

There are several statistical methods to estimate the parameters. One of the most widely used approaches is a Random Utility Maximization Multinomial Logit Model (RUM-MNL). This method tries to maximize the utility per alternative and estimates the parameters based on that. The MNL model is mainly suitable for an unlabeled choice set. This means that there are no alternative specific attributes and there cannot be any nesting nor is there an alternative specific constant. This is the case for this study. Other options are a nested model which considers preference for a certain alternative, and is commonly used in mode choice studies (e.g. predefined preference of car over train). Or a mixed MNL (ML) model. An ML model is an extend MNL model that includes an extra error term. It compensates for random taste variation and panel effects (Molin, 2014). This error term however is added to an alternative specific constant, which is not included in this research. Therefore, an MNL model is used to analyze the data.

The MNL model is based on the following utility function:

$ALTi = \beta_{biketime} * Biketime_i + \beta_{transfertime} * Transfertime_i + \beta_{traintime} * traintime_i + \beta_{price} * Price_i + \beta_{transfer} * Transfer$

As in the pilot experiment the software package Biogeme is used to analyze the data. The utility function is therefore incorporated in a Bison syntax. This syntax has the same structure as the one used in the pilot study.

5.2.2 Analyzable data

The quality of the data was relatively good. Only two rows were removed from the dataset, because not all questions were answered. For some questions respondents had the option to fill in an 'other' answer themselves. The benefit of this was that important, but missing answering options were revealed. This however barely happened. For most specific cases the other answers were grouped as 'other'. Only for employment the two 'other' replies were 'volunteer' and therefore 'other' was changed into 'volunteer'.

Furthermore, for analysis purposes the personal characteristics and habits were coded to make data selection easier. This made it possible to analyze data for certain types of respondents.

5.2.3 Separate and combined time components

One of the benefits of including all the time components is that they can be combined. This results in total travel time, a factor that can be compared to the factors transfer and price. This is important because about half of the respondents (Figure 10) claimed that they only valued the total time and not the separate time components. There are two disadvantages of combining the time components. First less information is calculated, since only the parameter value of the total time is acquired. Second the combined time attributes don't have equidistant values. This could lead to higher correlations between the attribute values (Molin, 2014). Nevertheless, these notions, the results will be more realistic, and thus more valuable, for the group that claimed to have valued the total time.

Figure 10 – Share of how respondents valued the time components

5.3 Results

First the parameter estimates are shown for the complete dataset of 269 respondents. After that the outcomes with a single time component are shown (Table 10). In the table, first the values are shown. They are the estimated outcomes and represents the impact on the utility. This is later used to show the interchangeability. In the second data column, the standard error is shown. This number shows the standard deviation of the mean. In the following column, the t-test value is shown and a last the p-value that indicates the significance.

Table 10 - Results based on complete dataset

Name	Value	Std err	t-test	p-value
Bike time	-0.19	0.0091	-21.02	0.00
Price	-1.77	0.0965	-18.33	0.00
Train time	-0.14	0.0061	-23.28	0.00
Transfer	-1.06	0.0669	-15.80	0.00
Time to park	-0.13	0.0155	-8.66	0.00
Single time comp.				
Time	-0.17	0.0095	-17.60	0.00
Price	-1.75	0.139	-12.65	0.00
Transfer	-1.05	0.0967	-10.84	0.00

All values are negative (i.e. utility goes down) and that is the expected sign. The T-test values are far from zero which show that deviation in the sample is relatively small. This results in highly significant values (1% level) which is supported by the low P values.

The values of the first column don't say anything when the used units are unknown. For time, minutes are used, for price; euro's and for transfer; the number of transfers. This means for example, that one minute of bicycle time brings utility down with 0.192. This can be applied to all parameters. Hence, 'utility' is the interconnecting unit. There is barely difference between the separated and combined time components. Therefore, the rest of the study will make use of the separate time components. However, in the dataset a distinction can still be made for deeper analysis in future research.

To show the interchangeability, the five parameters are visualized in five figures. In each figure one parameter is set to one unit, this is the base parameter. The values next to the arrows represent the value of the leashed parameter in its own unit. The units of the time parameters are in minutes, the unit of the price parameter is in euro's and the transfer parameter is an amount.

Bike time as a base

Examples:
One minute of bike time is equal to 1.36 minute of train time
One minute of bike time is equal to €0.11 (of parking price)

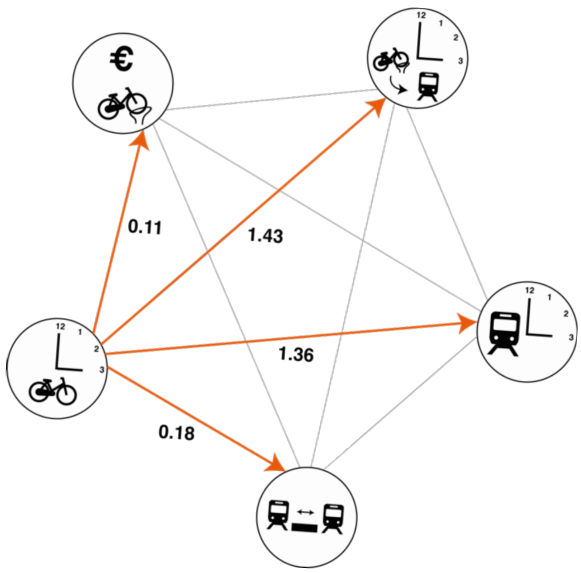


Figure 11 - Interrelation pentagon bike time base

Parking price as a base

Examples:
One euro for parking is equal to 12.6 minutes of train time
One euro for parking is equal to 9.2 minutes of bike time

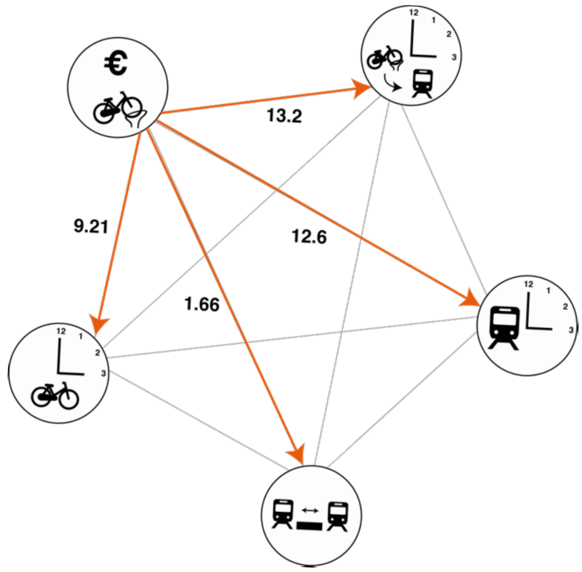


Figure 12 - Interrelation pentagon parking price as base

Time to park as a base

Examples:
One minute of 'time to park' is equal to 0.7 minutes of bike time
One minute of 'time to park' is equal to €0.08 (of parking price)

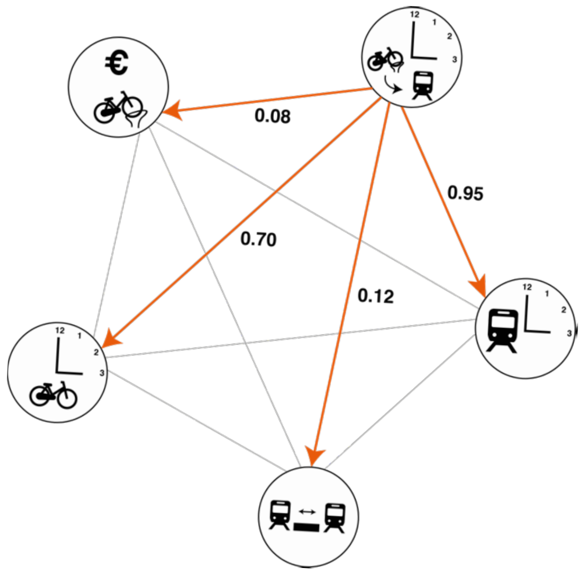


Figure 13 - Interrelation pentagon time to park as base

Train time as a base

Examples:
One minute of train time is equal to 0.13 transfer.
One minute of train time is equal to €0.08 (of parking price)

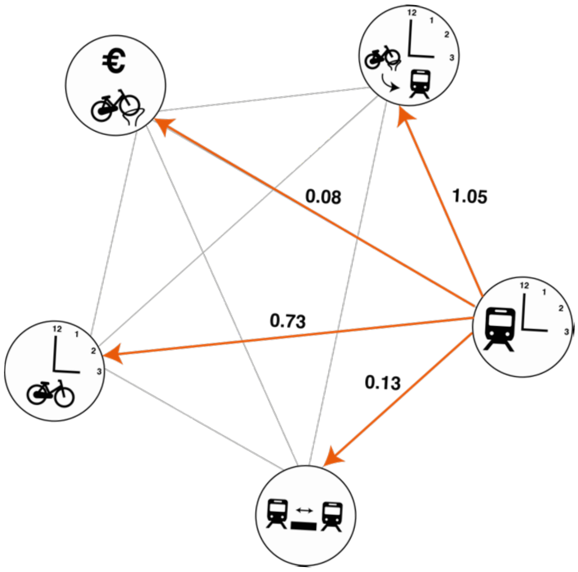


Figure 14 - Interrelation pentagon train time as a base

Transfer as a base

Examples:
One transfer is equal to €0.60 (of parking price)
One transfer is equal to 7.5 minutes of train time

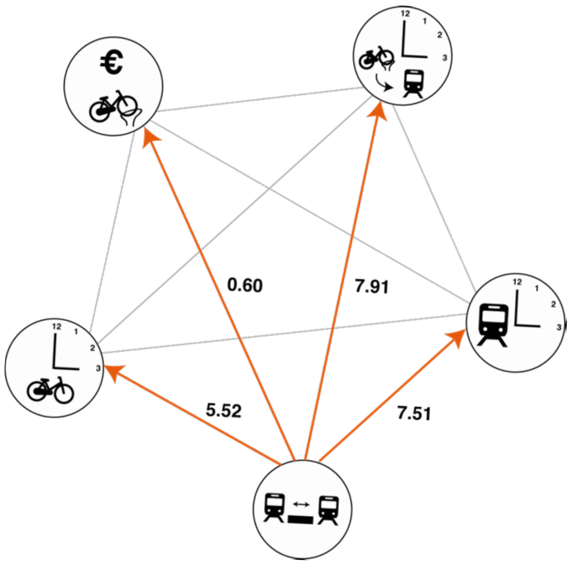


Figure 15 - Interrelation pentagon transfer as base

The outcomes show that the valuation for the trip parts is interchangeable. For example, that one minute of bike time is equal to 1.36 minute of train time. Which means that someone is willing to accept approximately 4 minutes of train time to avoid 3 minutes of bike time. This knowledge is valuable for influencing station choice. It can be used to generalize the 'costs' for a certain station. By decreasing or increasing the value of certain trip parts and their factors, the total value of a station can be altered. Making one station more attractive than another. The impact of this is discussed in chapter 6.

5.3.1 Results with interaction of personal characteristics and habits

The outcomes of the analysis are highly dependent on behavior, since behavior differs per person it is important to analyze the data with selected personal characteristics and habits. Scientifically this is important because it makes the outcomes more transparent, practically it is valuable because it makes the findings more usable and applicable to a problem in practice. For example, when the composition of a user group is known, the effect of a certain measure can be calculated more accurately. In Table 11 outcomes for different characteristics and habits are shown. Note that the outcomes can only be compared horizontally (between the factors) here since they are not normalized.

Table 11 - Outcomes per personal characteristic, MNL model (not benchmarked)

	Bike time	Price	Time to park	Transfer	Train time
General	-0.19	-1.77	-0.13	-1.06	-0.14
Gender					
Male	-0.20	-1.81	-0.16	-1.14	-0.15
Female	-0.19	-1.72	-0.10	-0.97	-0.13
Age					
15-	-	-	-	-	-
16-24	-	-	-	-	-
25-44	-0.21	-2.02	-0.18	-1.1	-0.16
45-64	-0.17	-0.90	-0.13	-1.13	-0.13
65+	-	-	-	-	-
Access mode					
Bicycle	-0.21	-1.88	-0.17	-1.14	-0.16
Walking	-0.20	-1.99	-0.16	-1.23	-0.16
Transit	-0.23	-2.27	-0.15	-1.38	-0.16
Car	-0.10	-0.90	-0.07	-1.15	-0.08
Labor situation					
Employed	-0.19	-1.57	-0.15	-1.15	-0.14
Student	-0.20	-2.35	-0.09	-0.93	-0.15
Unemployed	-	-	-	-	-
Travel purpose					
Work	-0.20	-1.75	-0.18	-1.18	-0.15
Study	-	-	-	-	-
Recreation	-0.19	-1.73	-0.11	-1.00	-0.14
Trips per week					
More than 3	-0.21	-2.15	-0.16	-1.13	-0.15
1 to 3	-0.20	-1.78	-0.13	-0.98	-0.15
Few times per month	-0.19	-1.56	-0.11	-1.17	-0.14
Barely	-	-	-	-	-
All shown parameters are significant at the 1% level. Not shown (hyphen) parameters were insignificant.					

The outcomes in Table 11 are mainly interesting when the focus is on the behavior of one characteristic. For example, to see how bike time and train time of females relates to each other. This shows that bike time is experienced 46% (-0.19/-0.13) more negative than train time by females. To compare the outcomes vertically the table should be normalized. In Table 12 the outcomes are normalized by setting price parameter to -1 for all characteristic categories. This makes it easy to see what 1 minute is worth.

Table 12 - Outcomes per personal characteristic, MNL model (normalized)

	Bike time	Price	Time to park	Transfer	Train time
General	-0.11	-1.00	-0.08	-0.60	-0.08
Gender					
Male	-0.11	-1.00	-0.09	-0.63	-0.08
Female	-0.11	-1.00	-0.06	-0.60	-0.08
Age					
15-	-	-	-	-	-
16-24	-	-	-	-	-
25-44	-0.10	-1.00	-0.09	-0.60	-0.08
45-64	-0.18	-1.00	-0.15	-1.30	-0.15
65+	-	-	-	-	-
Access mode					
Bicycle	-0.11	-1.00	-0.09	-0.61	-0.08
Walking	-0.10	-1.00	-0.08	-0.62	-0.08
Transit	-0.10	-1.00	-0.07	-0.61	-0.07
Car	-0.11	-1.00	-0.08	-1.23	-0.08
Labor situation					
Employed	-0.12	-1.00	-0.10	-0.73	-0.09
Student	-0.09	-1.00	-0.04	-0.40	-0.07
Unemployed	-	-	-	-	-
Travel purpose					
Work	-0.11	-1.00	-0.10	-0.67	-0.08
Study	-	-	-	-	-
Recreation	-0.11	-1.00	-0.06	-0.58	-0.08
Trips per week					
More than 3	-0.10	-1.00	-0.08	-0.52	-0.07
1 to 3	-0.11	-1.00	-0.07	-0.55	-0.09
Few times per month	-0.12	-1.00	-0.07	-0.75	-0.09
Barely	-	-	-	-	-
All shown parameters are significant at the 1% level. Not shown (hyphen) parameters were insignificant.					

The comparison between the different characteristics shows that between some there are barely differences while between others the differences are very large. The most notable differences are the ones between age categories (25-44 vs. 45-64) and between students and employed people. The value of time of the younger and studying people is much lower than the one of older or working people. This shows that it is harder to influence behavior of older and working people with pricing measures, on the other hand time measures will impact them more. For people between 25 and 44 and students the opposite is true.

The other notable differences do not count for value of time in general, but are differences between the factors. This shows that women are less hurried when parking a bike than men. And it shows that people that travel often (once a week or more) are less affected by a transfer than someone that barely travels. For car drivers, this effect is even stronger. This information is valuable when influencing the behavior of travelers. It makes it possible to target a measure to change behavior on a certain group. When taking measures that influence behavior it would be wise to focus on groups that use the station parking. Those people are not the ones that barely travel or often take the car.

5.4 Interpretation and validation

To check whether the outcomes are understandable and are valid, the choice experiment results are presented to experts and compared with literature. This section focuses on the content of this interviews. The methodological structure of the interviews can be found in chapter 6, the reason for this is that the interviews play a larger role in that chapter. First the interpretation is discussed, followed by the validation.

5.4.1 Interpretation

An interview started with an introduction about the research and method. The respondents in the interviews were shown the general outcomes, together with a translation to the willingness to pay of the time components and the train transfer. This value of time was calculated based on the parking price. The reaction of the respondents gave insight to whether they understand the outcomes. All understood the outcomes after the general introduction. However, some valuable feedback was acquired. The feedback is shown below.

- Half of the respondents noticed that the mentioned outcomes are just a few of the factors that play a role.
- The fact that a value of time is shown suggests that this study tends to focus on pricing measures.
- It was unclear that the value of the time components is in minutes while the value of the transfer is a (single) penalty.
- Because money is chosen as a central connector, it might suggest that the other factors have no interrelationship.
- The advice was given to visualize the interconnection.

The remarks give valuable insights about the understandability of the results to make the outcomes more understandable.

5.4.2 Validation

The interviews were also used for validation. The outcomes might seem very strong at first sight, after all they are based on a commonly used method. In this section the key components that came out of the interviews considering validation are put apart. A link with literature was made, when literature was available. When misinterpretations about the results were noticed in the interviews, then those were corrected by the interviewer.

The connection with values of time that were discovered in other studies was rapidly made. The values are a bit low compared to other studies, but still in an assumable range. Something that could be the case is that the choice experiment described a situation where mode choice was already made. Therefore, travelers are already willing to use this mode. Something else that differs to what might be expected is that the parking time (defined as time to find a parking spot and walk to the platform) has a less negative impact than bike time and an approximately equal impact as train time. Remarkable because this is one of the most 'chaotic' parts of the trips, and it is kind of a transfer, which is generally valued very negative. A reason for this could be that parking is per definition a part of a cycling trip. A part of the negative impact could therefore be already in the valuation of bike time.

Bike time is found to be costlier than train time, which seems valid because it costs more effort. It has about 40% more impact. This leads to a travel time factor[2] of 1.4. This is slightly lower than in previous studies. When looking at the transfer penalty it is about 60 cents. Comparing this to train time which is 8 cents per minute. The time penalty of a transfer would be 7.5 minutes. With a transfer of 5 minutes this would be a travel time factor of 2.5. It is valuable to compare this with research that has been done on those factors.

To compare the comments on time components, they are placed next to literature about value of time and time factors. There is not a singular value for value of time in literature since it is very context specific. But it ranges from about 5 euro (Antoniou, Matsoukis, & Roussi, 2007) to about 20 euro's, with a Dutch average of 9.25 euro (Warffemius, De Bruyn, & Van Hagen, 2016). The value of time that can be calculated from the choice experiment ranges from about 5 euros to 6.50 euro. This is despite that it is on the bottom, still within the range that can be found in literature. When comparing the penalty for a transfer with literature a range of 5-15 minutes is considered realistic (Warffemius, De Bruyn, & Van Hagen, 2016). The penalty of 7.5 minutes that was found in this study is in that range.

5.5 Generalizability

In the choice experiment that was executed some groups were overrepresented. Therefore, the conclusions of this experiment are not one to one generalizable to society. This might not be a problem since this study tends to draw conclusions for bicycle train users. Bicycle train users are not a reflection of society themselves. This section compares the personal characteristics of the respondents to the personal characteristics of train users.

The age of the respondents is compared with the age of NS travellers (Van Hagen & Exel, 2012) in Figure 16. This shows that the age distribution of the respondents of the choice experiment differs from the distribution of train users. The age categories 16-24 and 25-44 are overrepresented while the other categories are underrepresented. Since the parameter estimates differed between the age categories 25-44 and 44-65 this might have resulted in an underestimation of the overall value of time. At the same time, also the youngest category is underrepresented which might compensate for this effect. This however couldn't be checked because the outcomes for the other age categories were insignificant.

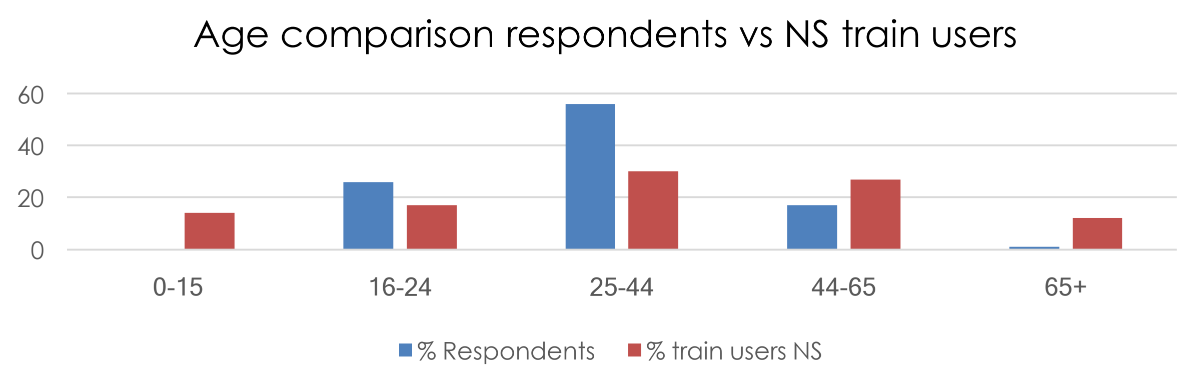


Figure 16 - Age comparison of respondents and train users (Van Hagen & Exel, 2012)

[2] Measure for valuating time components. For example, when traintime has a factor of 1 this means that 5 minutes is experienced as 5 minutes, while if biketime has factor 1.2 this means that 5 minutes is experienced as 6 minutes.

There is another factor that influences the generalizability and that is that about 80% of the respondents are highly educated (HBO and University). Figure 17 shows the educational composition of the respondents. Research has been done to the users of the bicycle train mode. This research indicates that users are in general highly educated (Huisman, Van Oort, & Shelat, 2017). The overrepresentation in the sample therefore doesn't impact generalizability. Figure 18 shows the visualization of the composition of the bicycle train users.

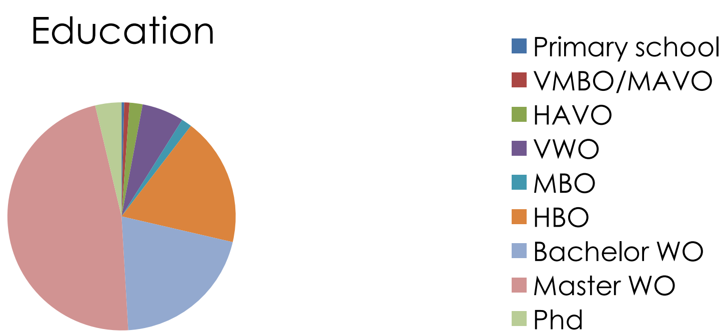


Figure 17 – Education level of respondents

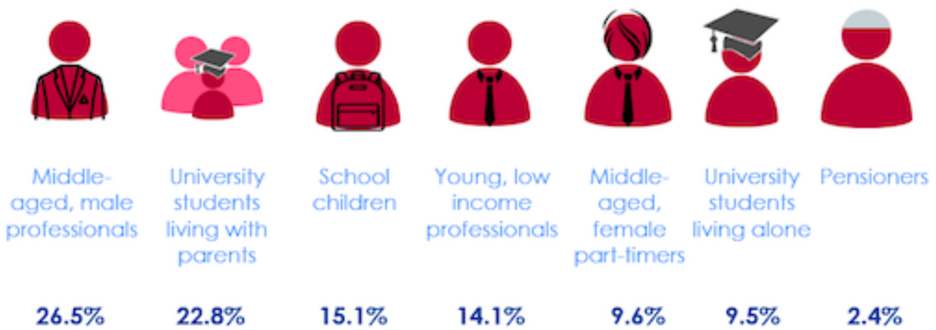


Figure 18 - User groups of bicycle train mode (Huisman, Van Oort & Shelat, 2017)

Also, the level of income influences generalizability. Figure 19 shows that there is peak of respondents with an income higher than €50,000. Accurate information about the income of train travelers is not available therefore a detailed comparison cannot be made. However, this distribution is a-typical, this might harm generalizability. It could have resulted in an overestimation of the overall value of time, since people with higher incomes have more to spend.

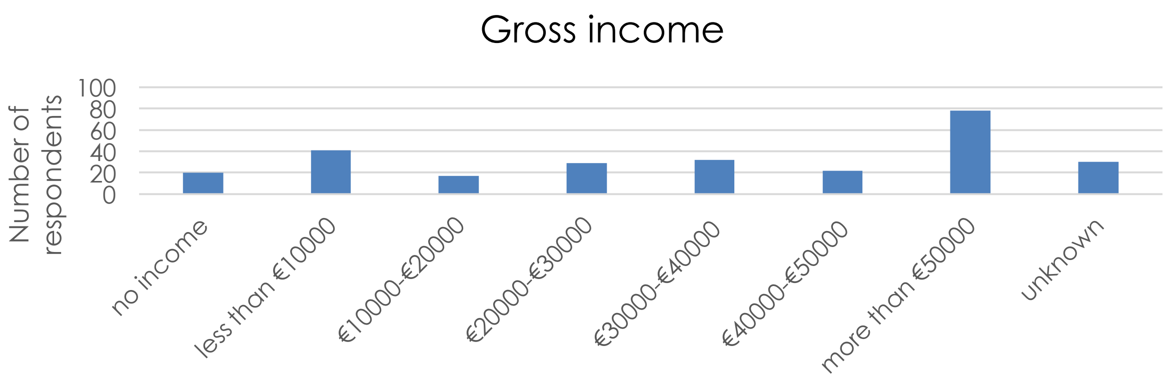


Figure 19 – Income (gross family) of respondents

The geographical location of respondents could be of influence on the generalizability. Figure 20 shows that most respondents live in the Randstad area. Therefore, the outcomes are not generalizable to all parts of the Netherlands. This however doesn't harm this study since it focuses on station choice, something that mainly appears in the larger cities.

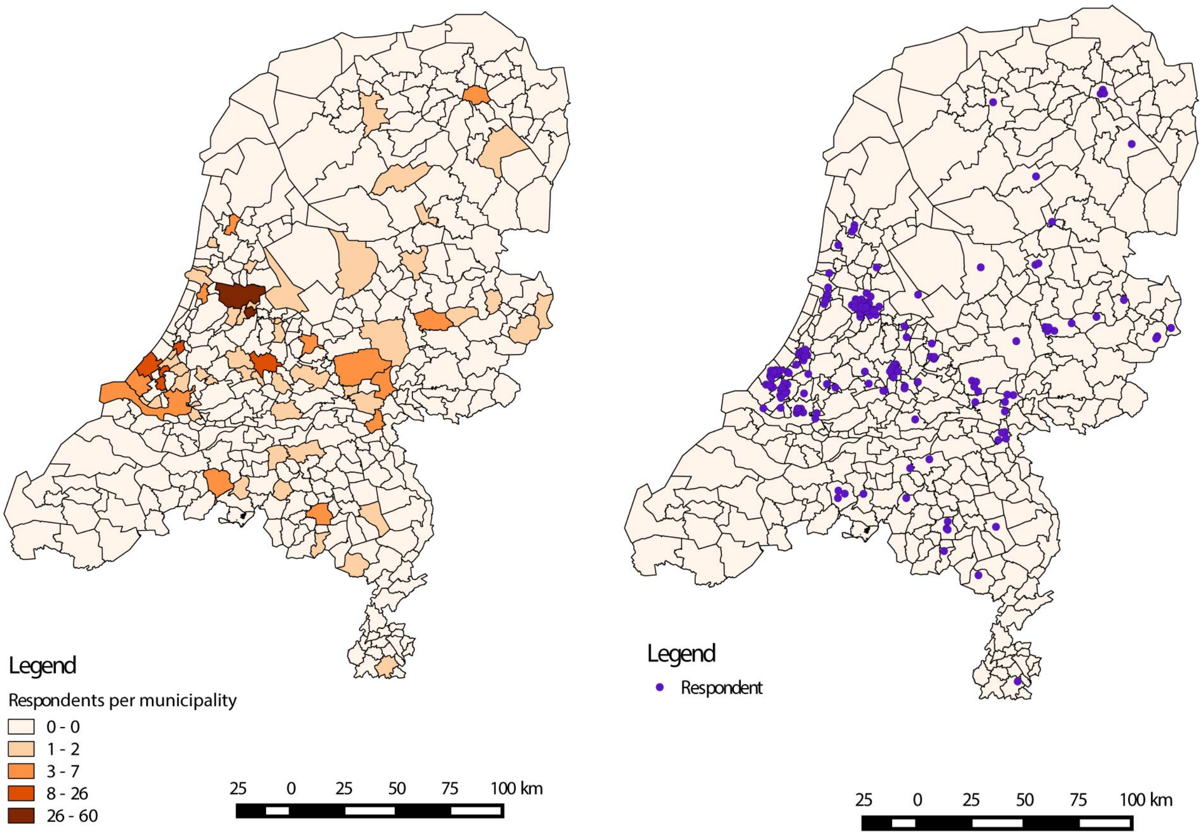
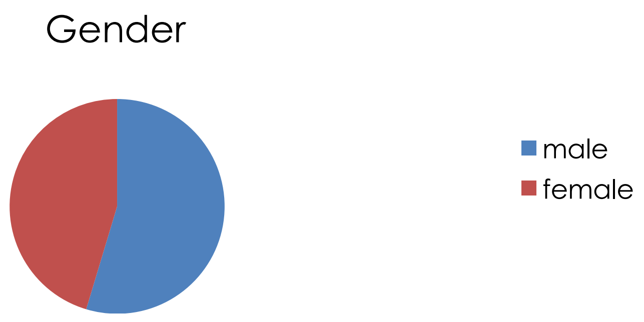
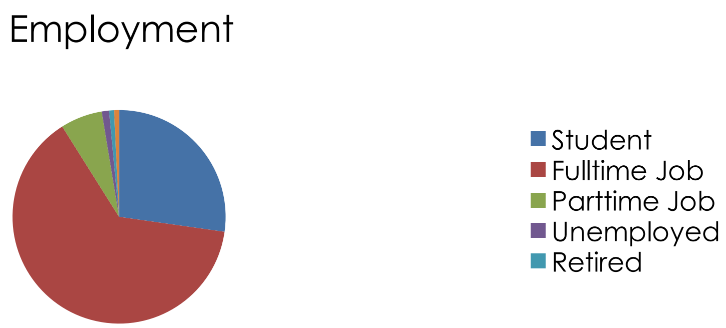


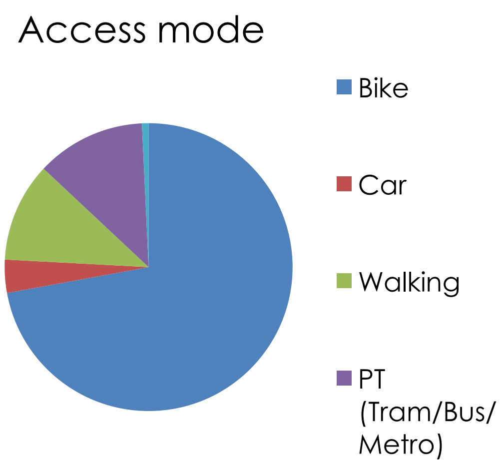
Figure 20 - Town of residence of respondents (left) and location of respondents (right), n=269

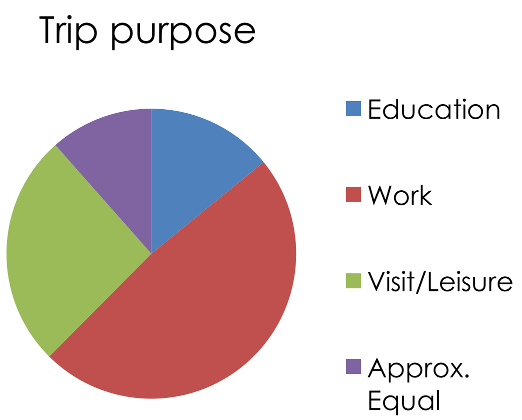
5.5.1 Other characteristics of respondents

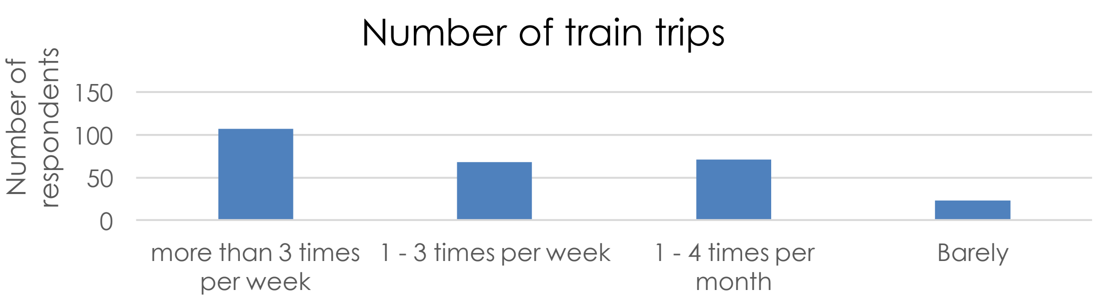




5.5.2 Habits of respondents







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5.6 Conclusion

As the third and last step of the fundamental part, and as the empirical core of this research, the choice experiment is the foundation of this thesis. It answers sub question number three by giving insight in how the influencing factors of station choice relate to each other. Because all factors are interconnected also other interrelations can be made. The outcomes were presented to a group of experts who considered them in general valid. The composition of the respondents was not always a representation of the population. Mainly age and income have overrepresented categories. This might have an impact on the overall estimates. Nevertheless, the experiment showed that there is a specific value for all time factors in the process of choosing a station. The monetary factor is formed by the price of parking the bike at a station. Besides the value of time, there is also a value of transfer, this shows what someone is willing to pay to avoid a transfer. For example, the willingness to pay to avoid a transfer. It suggests that behavior can be changed by tuning the factors and making a station more or less attractive.

6 Influencing station choice

This thesis consists of two parts, it started with the fundamental stage that had the goal to find the influence of factors that play a role in station choice. This stage is followed by the policy stage, which aims to use the findings to solve the problem of parking pressure at stations. The goal is to come up with a set of possible measures to influence station choice. This set includes the pros and cons of each of those measures. Interviews are held to come up with the solutions. Because there is no specific literature on influencing station choice the character of this stage is explorative. The opportunities of influencing behavior are pointed out based on generic literature.

6.1 Generated fundamentals

In the fundamental part of this thesis the factors that influence station choice were derived in three steps. A wide variety of factors was discovered. Those factors were ranked and the most influential factors were used in the choice experiment. Figure 21 visualizes the steps taken. In the figure the green factors are directly included in the choice experiment, the orange factors were included as a combination. Of Those five most important factors the interchangeability was calculated. In the figure, they are shown in compared to parking price (which is in euro's) however, it is possible to show it in any of their units.

Because the most detailed information is available about the 5 most important factors, the generation of the set of measures will only focus on those five factors. It is however important to note that this doesn't mean that the other factors don't play a role in the station choice process.

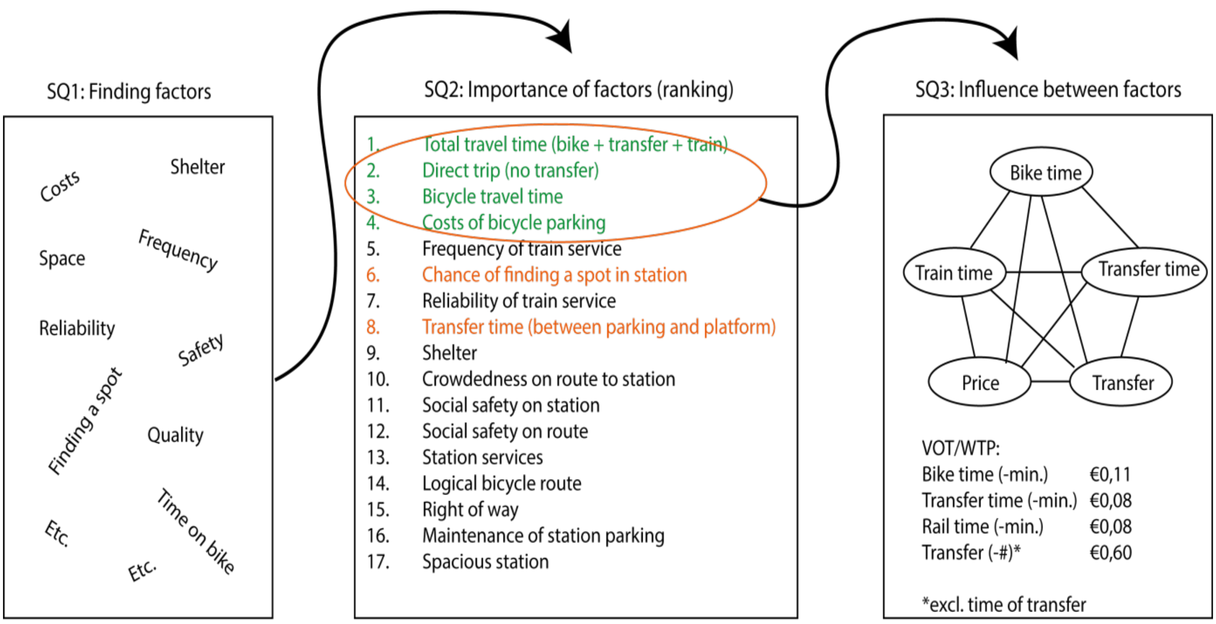

Figure 21 - Overview of steps taken in fundamental stage

6.2 Background of influencing behavior

Influencing behavior is something that is occurring more and more within the mobility field. It is often used to solve congestion problems. This is new compared to the classical approach of increasing capacity. Those new approaches are mainly motivated by cuts in public funds and awareness about the effect of increasing capacity (Banister, 2008). This background story gives a brief introduction in influencing behavior in general. After that it dives into behavioral change in mobility. At the end, some information is given about a concrete program in the Netherlands that sees a large role for influencing behavior: beter benutten.

Influencing behavior is something that has a long history. One of the most common processes of influencing behavior is the nurturing process of children. Children 'accidently' do things that are either considered good or bad. Parents either punish or reward because of this behavior. In this way behavior is changed. This process never stops; children grow up and the role of the parent diminishes and society takes over. Companies are competing for the favor of the customer. They are influencing our shopping behavior by price incentives. For a lot of people this price incentive is an important factor, however reality shows that we are not a perfect homo economicus. For example, when we want something overprized because it gives us a good feeling (French, 2010). This shows that influencing behavior is not a simple matter of decreasing prices, there are a lot factors to influence. This also counts for influencing behavior in mobility.

The concept of influencing behavior in mobility is as old as the hills. When something became more easy, faster or cheaper it became more attractive and more travelers started to us that something. This is mainly based on the economic theories that still hold today. Nowadays influencing behavior in mobility is more and more used to cope with congestion problems (Becker, 2008). Because we all have the same rhythm, traffic is not equally divided over the day. This leads to congestion. There are two options to reduce that congestion: increasing infrastructure capacity and spreading the demand. The first one is very costly and has impact on the environment. The second option requires influencing the behavior of travelers. Either by making driving outside rush hour more attractive or driving within less attractive. Based on this concept congestion charging was introduced in London in 2013 (Eliasson, 2007)

An example where behavior is influenced in the mobility field is the 'beter benutten' program in the Netherlands. As a part of this program, road users were rewarded when driving outside rush hour (spitsmijden). As a reward, they either got cash or free train tickets. Currently those projects are mainly used to spread drivers during construction works (Beter Benutten, n.d.). However, that it works shows that it could also work in normal operation. Spitsmijden is something that recently has found his way to public transport in the Netherlands. MyOV is a project were people that travel with trains outside rush hours can save credits. They can use those credits to buy products and gifts in a store (MyOV, n.d.). A backside however is that for the MyOV project the interest of users seemed to diminish over time. The effect of behavioral change is not something of which the effect is always everlasting.

6.3 Influencing station choice by a set of measures

In this section a set of measures is created that can influence station choice. First it is explained how those measures are found, followed by the measures themselves.

6.3.1 Approach

To generate measures that can influence station choice, interviews are held with a set of experts and stakeholders. This was not the only reason to conduct interviews. They were also used for validations and checking interpretations of the outcomes of the choice experiment (section 5.4). In this section first the design of the interviews is discussed, followed by the selection of respondents (interviewees). At the end the analysis of the interviews is discussed.

6.3.1.1 Interviews

The interviews are semi-structured (Bryman, 2008), this means that there is a structure in the interview to the level that certain subjects need to be discussed. In contrast to a structured interview were a fixed list of question is asked. The benefit of semi-structured is that it assures that all subjects are discussed but that it also gives room to explore new solutions and discuss unpredicted subjects. This is valuable for the explorative character of the policy phase.

The interviews consisted of three parts. First the results of the choice experiment were discussed and respondents were asked about how they interpreted the results and whether they considered the outcomes valid. The second part was used to ask respondents what options there are for influencing station behavior –in the light of the found parameters- and what the pros and cons of those options are. At last respondents were asked about the influence of information and what extra information services could add.

The respondents were told that there will be no direct links to their responses in the thesis. This is to prevent an answering bias because of certain interests that might play a role. Therefore, respondents are not directly linked in the text, nor are the interview reports in the appendix.

6.3.1.2 Selection of respondents

The two sided goal for the interview phase sets requirements for the respondents. They need to be experts in science or policy but not necessarily in both fields. It is in fact very valuable to see how outcomes are interpreted by someone that is not into the methodology, and to see the policy measures of someone that is not working in policy.

One of the drivers of this study was the 'Governance agreement bicycle parking'. This agreement stated that alternative solutions to cope with parking pressure should be found. Influencing station choice could be one of those solutions. Several organizations are a part of this agreement, the persons behind these organizations are valuable respondents for the policy part. To add focus on the interpretation and validation in the interview part, people with expertise in the scientific field are also asked to respond. For efficiency reasons, sometimes someone from one of the organizations is asked that was not involved in the agreement but is working as a researcher. In that way including people from the agreement organizations and including scientific expertise could be combined. Table 13 shows the organization of the respondents and their job title. Appendix D includes a list of their names.

Table 13 - Overview of respondents

Organization	Job title
NS Reizigers	Transport researcher
NS Stations	Chain manager NS stations
ProRail	Transport researcher
Ministerie I&M/APPM	Consultant bicycle I&M
Ministerie I&M/KIM	Researcher
Gemeente Amsterdam	Policy officer bicycle
Vervoerregio Amsterdam	Policy officer bicycle
Fietsersbond	Policy influencer
University of Amsterdam	Researcher

6.3.1.3 Analysis of the interviews

Of all interviews a report was written. Those reports were analyzed by executing a content analysis. A content analysis aims to structure the responses in an interview. This is done by categorizing the answers (Schreier, 2014). To do this content analysis in a structured way the software package atlas.ti is of use. The main function is to structure texts. The categories and labels of this analysis can be found in appendix D and the outcomes of this analysis are discussed in the next section. The content analysis made it possible to count the number of respondents that mentioned a certain measure. This number is mentioned between brackets in the next section. The amount of times a measure is mentioned doesn't say anything about the strength of the measures, since the goal was mainly to get an overview of all potential measures. However, it improves the repeatability of this study.

6.3.2 Findings

The line of reasoning is that by influencing station choice of travelers the parking pressure at certain stations can be reduced. This happens when travelers spread more evenly over a set of stations instead of all going to one. In general, there are three main fields that influencing measures can be based on. Those are the three trip parts: access trip, at the station and the train trip. This basis can form any other combination, for example a measure that influences all trip parts. The content of this section is entirely based on the responses of the interviews. The measures are being discussed in the trip order (access trip, at the station, train trip and combinations of those). For measures difficulties of certain natures (technical, financial, behavioral and political) might occur. This classification is determined by the author based on the mentioned cons.

6.3.2.1 Access trip, influencing bike time

There are several ways to influence bike time. First it is possible to stretch routes. Stretching routes shortens distance and might increase average speed. It reduces the time to get from A to B (5 interviewees). There are however a few problems with this approach. First the effect of stretching a road cannot always be directly allocated to a certain station. The further the measure from the station the less visible the effect is. Besides that, it is not always possible to stretch routes in the build environment due to obstacles. And when it is technically possible expensive structures like flyovers might be necessary. Technical and financial problems may occur when using this measure. However, in certain situations with large flows it might be an effective way to impact utility and change station choice.

Another option that doesn't demand changes in the location of the road is increasing right of way for bikes (3 interviewees). This can be done by changing traffic rules or giving more green at crossings with traffic lights. The difficult thing of this is however that it brings up a battle of the modes. It requires a preference for a certain mode. This is therefore an option that often cannot be made without harming other modes. Political problems may occur when opting for this measure. It might however be an easier way of influencing station choice than by stretching roads.

6.3.2.2 At the station, influencing parking price and time to park

Pricing is an interesting option to influence station choice. It will certainly move some people away from the station because it influences utility. Some travelers are more price sensitive than others (based on acquired parameters in section 5.3), so for certain groups it will have more impact than for other groups (5 interviewees). A risk of pricing is that it will also move people away from the bike as an access mode. This mode change might lead to busier local public transport, which is often heavily subsidized. Or a move to the car. Since station parking's are not an island it might also lead to misuse of public space. Next to that it will only change station choice when all parking's at a certain station have pricing. Otherwise free parking's get overcrowded while the priced once will remain underused. Those risks are mentioned by all interviewees that mentioned pricing. Potential problems are mainly from a behavioral nature.

In a lot of cities in the Netherlands an innovative direction of pricing is implemented. It is pricing with the first 24 hours being free. This mainly prevents misuse but will not force people to use another station. By decreasing the number of free hours, it might force some people to cycle to another station (1 interviewee). Because the average price paid by a user increases, this is an alternative form of pricing. The disadvantages are almost the same as with normal pricing, the difference however is that differentiation is possible on parking time instead only on price. This can help reducing the risk.

Another option is to turn pricing upside down. Not punishing users, but reward users that pick a less crowded station (4 interviewees). This measure is promising since there is no risk for mode change, nor it impacts the public space. Also, a lot of positive experience in other mobility fields is gained, for example 'filemijden'. The backside of this however is that it directly costs money instead of generating income. Next to this there is a serious risk for moral hazard. You start rewarding people to let them stop doing things that you don't want them to do. While you don't reward people that were already having the right behavior. Potential problems are therefore from a financial and behavioral nature.

To reduce the time that is needed to walk to the platform, a parking must be situated as close to the platform as possible (3 interviewees). The potential of this measure is mainly in the fact that is often more easy to build new parkings at stations that still have residual capacity. If it is impossible to reduce the straight-line distance, the number of detours is reduced. For example, creating a parking exit that is directed towards the platforms. Potential difficulties are highly contexts specific and mainly financial and space wise.

Something that could also help is implementing easy access and fast lanes at the entrance of the station parking (5 interviewees). This could reduce the time to park. When these systems are implemented at a station that station becomes more attractive. Disadvantages are that implementing these systems require extra space and are costly. Another possibility is leading travelers the way to the free spots. This is already implemented in some station parking's in the Netherlands (like Delft). In front of every row there is a sign showing the current number of free spots. A disadvantage could be that these systems are relatively expensive. This is a form of easy access.

6.3.2.3 Train trip, influencing train time and amount of transfers

The third trip part that can be influenced is the train trip. To reduce train time or the amount of transfers, adjustments in the schedule should be made (7 interviewees). For example, increasing the amount of intercity stations. This is a difficult process but on the other hand is has a lot of potential for influencing station choice. Now, intercity stations are often situated at the destination station, while the potential of departure station might be as large. Moreover, there are sprinter stations in the Randstad area that have more potential than intercity stations outside that area. This might be reason to look at the current systematic. The downside of renewing the schedule and increase the number of stops is that it highly effects current intercity users, that travel between two existing intercity stations. Potential problems will therefore mainly be of political nature.

Another option to reduce travel time is to increase speed e.g. to 160 km/h (1 interviewee). By letting the trains run faster travel time is reduced. This is not necessarily an option for station choice influencing since it will probably effect all stations, and not make a single station more attractive than another.

6.3.2.4 Combinations

A measure, that might influence all the aspects is increasing the availability of information (9 interviewees). Information doesn't directly influence the factors but it makes it possible for travelers to valuate factors in a more objective way. Station influence is possible to provide more information about one station than about another. For example, with dynamic route signs along the road. Sometimes influencing based on factors is not even necessary. For example, in the case when travelers now do not take the optimal route but will take one if they have the information to make the right judgment. Implementing route signs will however need large investments while bringing all the data together might be technologically complex.

6.3.3 Overview and valuation by author

The measures that were generated are summarized in Table 14. To give an indication about the impact and effort of a measure they are rated on two aspects. Impact of influencing and effort to implement. Valuation is executed by the author and based on the experience in the field that was acquired in the period that this study was executed. Therefore, it should be mainly seen as an indication and not as hard figures. Figure 22 shows the plotted values. This figure can also be used to identify the measures that have the highest potential for implementation. Those are the measures with the highest impact and the least effort to implement. This shows that pricing measures (incl. rewarding) as well as creating spots close to the platform (at smaller stations) are the best measures to start with. Those measures are followed by the measures on the main diagonal: right of way, easy access/fast lanes, improving information and changing schedules. At the bottom, there are: stretching routes and increasing speed. Note that this valuation is highly impacted by context. It is possible that in some cases measures that seem least favorable can be the best.

Table 14 - Valuation of measures.

Category	Name	Difficulties	Effect on influencing	Effort to implement
Access trip	Stretching routes	Financial, Technical	2	4
	Right of way	Political	3	3
At the station	Pricing	Behavioral, Political	4	3
	Pricing (reducing free time at 24h free parkings)	Behavioral, Political	2	1
	Rewarding	Financial, behavioral	4	2
	Parking close to platform	Financial, Technical	3	2*
	Easy access and fast lanes	Financial	3	3
Train trip	Change schedule	Political, Technical	5	5
	Increase speed	Financial	1	5
Combination	Increase Information	Financial, technical	4	4

*** at stations that still have space available for extra parking spots.**

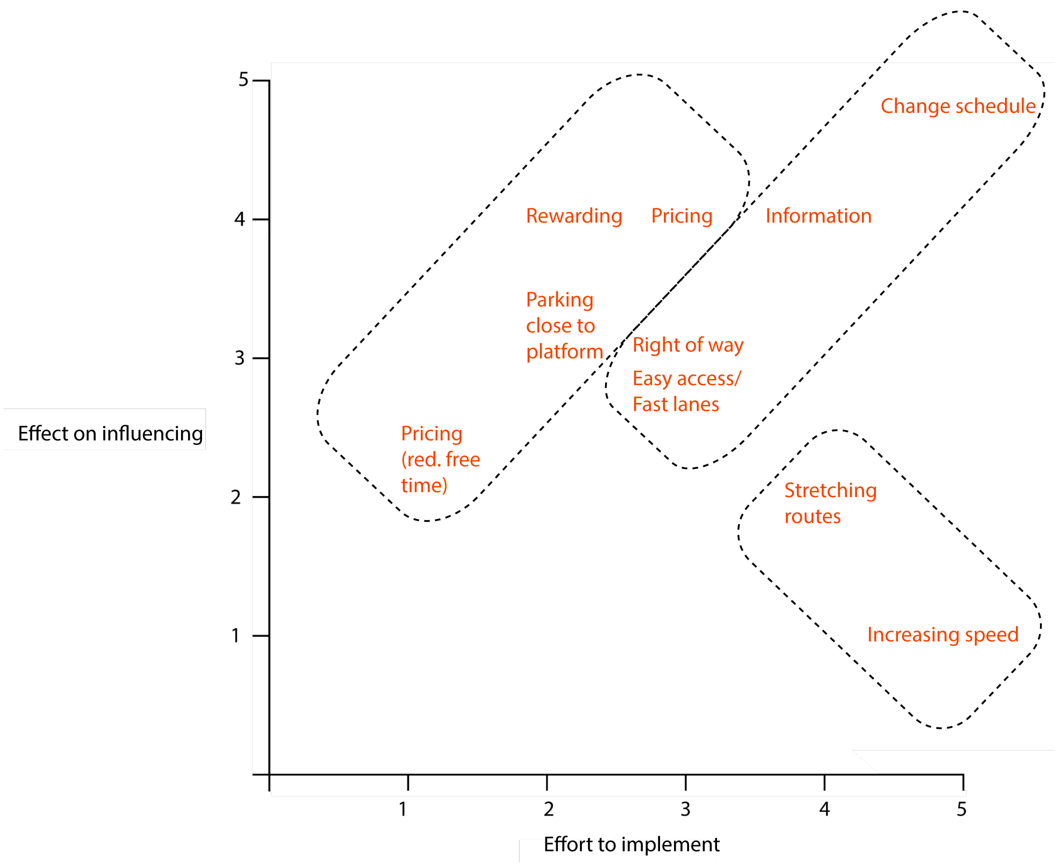

Figure 22 - Plotted ratings of measures

7 Illustrative case

This chapter has the purpose to show what an implementation of the possible measures to influence station choice would look like. Measures that were generated in chapter 6, and their specific impacts that were found in the choice experiment are applied on a geographical case in the Netherlands. The choice experiment was generic, this means that the acquired parameters are based on a context that doesn't exist in reality. That context approximated a station choice context in the Netherlands. To show the potential of measures it helps to put the measures in an existing station choice situation. Normally the outcomes for one context cannot be copied one to one to another. Here however it is assumed that the fundamental outcomes can be applied on a real situation (case). The case is the choice between the stations Amsterdam Zuid and Amsterdam RAI (from here also mentioned as Zuid and RAI). The reason to use this case is that Amsterdam was mentioned as an example by several interviewees. First the current situation is explained, followed by an explanation of how the station choice can be influenced. At the end the risk of the measures and the impact on stakeholders is discussed.

7.1 Current situation

Zuid and RAI are both stations on the south axis of the ring railroad of Amsterdam. They are intercity and local train station respectively. At Zuid, there are severe problems with parking capacity, mainly at the north side of the station. At RAI there are still plenty of parking spots available at the recently build entrances. Those spots are right under the platforms, which makes it very easy to access them. At Zuid parking a bike is free for 24 hours, when that time is exceeded a fee is charged. A bit further from the station completely free spots are located, although often without any capacity left. RAI also has the 24 hour regime and has free spots on the east side of the station.

Someone coming from the Scheldebuurt (origin) that wants to take the train to Almere has two logical options; Zuid and RAI. Zuid has intercity connections but parking is not very attractive due to crowdedness. RAI only has sprinter connections, but also a surplus of parking spots at any time of day. Besides that, it is closer to the Scheldebuurt. Some people don't cycle to the closest station (RAI) but go to Zuid, because it has a direct connection and the train time is slightly faster. In Table 15 the figures of the trip parts for this station choice are shown. The figures are based on google maps data and the 2017 railway schedule (NS, 2017).

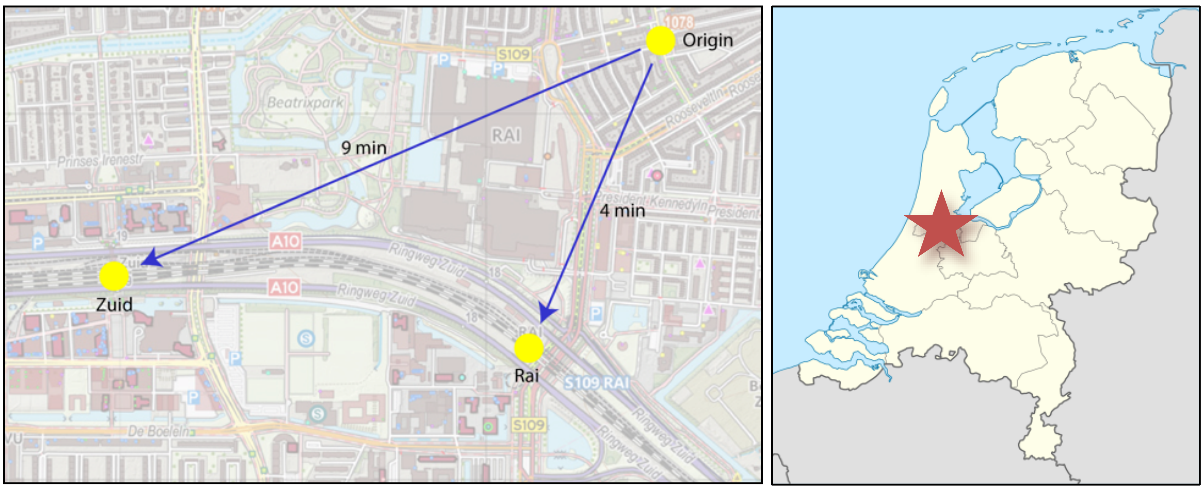

Figure 23 - Case geography

Table 15 - Case data

Departure station	Zuid	Rai
Bike time	9 minutes	4 minutes
Parking time	2 minutes	1 minute
Parking to platform time	3 minutes	1 minute
Train time to Almere C	19 minutes	26 minutes
Total	33 minutes	32 minutes
Number of transfers	0	1
Trip costs	€5.80	€5.70
Parking costs	€0.00 (1st 24hrs)	€0.00

In this case, both options seem equally attractive considering travel time and trip costs. Zuid is a bit more attractive because it offers a direct connection. This would make Zuid the preferred option. As the choice experiment showed, not every trip part is valued equally. To make both stations completely comparable, the figures should be converted into the same unit. By monetizing the time components and transfer, the stations become comparable. Table 16 shows this monetization. The monetizing factors were acquired in the choice experiment.

Table 16 - Case data, generalized before measure

	Zuid	Monetizing factor	Zuid (monetized)	Rai	Monetizing factor	Rai (monetized)
Bike time	9	0.108	€ 0.972	4	0.108	€ 0.432
Parking time	2	0.075	€ 0.15	1	0.075	€ 0.075
Parking to platform time	3	0.075	€ 0.225	1	0.075	€ 0.075
Train time to Almere C	19	0.080	€ 1.52	26	0.080	€ 2.08
Number of transfers	0	0.599	0	1	0.599	€ 0.599
Trip costs	€5.80	1	€ 5.80	€5.70	1	€ 5.70
Parking costs	€0.00 (1st 24hrs)	1	€ 0.00	€0.00	1	€ 0.00
Total			€ 8.67			€ 8.96

The monetization and calculation confirms that Zuid is the most attractive station due to its lower generalized costs. When the assumption is made that a person living at the origin makes a rational choice he or she will opt for station Zuid.

7.2 Influencing the station choice

By pursuing people that now opt for Zuid to change to RAI a part of the parking pressure can be spread. To convince a person to opt for RAI, the generalized costs of RAI should become lower than the generalized costs of Zuid. By implementing measures the attractiveness of stations can be altered. The options for this are this are numerous. Any combination of the in chapter 6 shown measures is possible to influence the attractiveness of trip parts. However, it would be wise to start with the measures that have the highest impact and cost the least effort to implement. Those measures are building new parkings close to the platforms and implementing pricing measures. The first measure cannot be used to influence the station choice, since the parking at RAI is already very close to the platforms. Implementing pricing however is an option.

Increasing the parking price at Zuid could exactly fill the difference of 29 cents. In theory 30 cents would be enough to make RAI the better option. However, in practice people are not completely rational. They will not change their habits because they save one cent. Furthermore, rationality differs per person. Some might change their habits to gain one cent, but others will never change their habits. By implementing some extra measures the chance that travelers alter their station choice becomes higher.

- Parking price is raised with an extra 20 cents to 50 cents per day.
- Implementation of ERTMS[3] makes it possible to reduce the follow up time, the transfer time in the train trip from RAI to Almere is therefore reduced by 2 minutes. The sprinter train time is therefore also 2 minutes less. The intercity train time remains the same.

This leads to a new situation were the generalized costs of Zuid are € 9.17 and of RAI are €8.80. When looking at this table, RAI is the winner, it is 4% cheaper than Zuid. This percentage is not groundbreaking, however when looking to the goal of influencing station choice this does not matter. The purpose was only to move some of the travelers to other stations, not everyone. When everyone would choose another station, the problem would only be moved to that station. The concept of spreading parking pressure mainly works when an appropriate share moves to another station. Even when it is only 5% of the users decides to go to RAI it will help to reduce the pressure at Zuid.

The risk of implementing pricing measures is that some travelers move to another mode, or start parking their bike in public space to avoid parking costs. It also requires that the successful 24 hours free regime is being changed into a paid regime. Furthermore, the measure will only work if all parking's at Zuid charge a parking fee. Especially those risks may impact stakeholders firmly. It impacts the NS because travelers use their car instead of the train. And it impacts the municipality of Amsterdam because public space around Zuid might become a mess. Besides that, the municipality might be faced with extra cars in the city because of the mode choice. Also, interest groups like Fietsersbond and Rover might disapprove because it restricts freedom of choice for travelers.

Convincing stakeholders that those measures will improve the current situation is a part of the process. A discussion with the stakeholders might lead to other measures that have less risk, but cost more effort to implement, and have less effect. For example, improving the right of way. The measure that has the most impact (changing the railway schedule) might also be considered. By letting some intercity trains stop at RAI it becomes most attractive for some people. This measure doesn't have the risks that pricing measures have, but it would require a completely new view on the railway schedule. Furthermore, a stop at RAI can only be justified when the demand is high enough. Otherwise the benefits would not cover the time losses of the passengers that do not board at RAI. This shows that the best set of measures for this case is not only dependent on a static calculation but also on what risk certain stakeholders accept.

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[3] ERTMS is a new European safety and control system for railways. It is supposed to reduce minimum follow up times.

7.3 Conclusion

This chapter illustrated that it is possible to change the attractiveness of Amsterdam Zuid and Amsterdam RAI by implementing measures. This could be a useful way to spread the parking pressure over the two stations. In this case, it would be useful to start with the measure that has the most potential: pricing. Because people are in general not rational, the difference in attractiveness of stations should be substantial. The larger the difference, the larger the chance that they will change behavior.

There are risks in implementing pricing measures, since it might influence mode choice and could lead to a mess in public space. This would mainly impact NS and the municipality of Amsterdam. Therefore, other measures might be considered in a discussion with stakeholders. Measures like 'right of way' and changing the train schedule. Further research or starting a pilot could help quantifying the risks. A quantification of the risks within a case could help in setting up the optimal set of measures for that pilot.

8 Conclusion

The subject of this thesis concerns station choice of travelers that access a railway station by bicycle. Besides extending knowledge on this subject it also looks at the applicability of this knowledge to influence station choice as a solution for parking pressure at railway stations.

The research question of this study is: *On what factors do 'bicycle-train' travelers base their station choice when accessing the railway network, how are those factors related and what are measures to influence this choice based on those factors?* The answer to this question is put apart here. The conclusions are drawn within the limitations of this study, later in the reflection the limitations are being discussed.

Many factors play a role in station choice. Factors that influence the bicycle or access part, the ones that influence the station part and the ones that influence the train part. Besides the factors that directly influence the choice, there are external factors: personal characteristics of the travelers and context variables like weather and trip purpose. Those factors have an effect on the valuation of the direct factors. An overview of the factors that were found is shown in Figure 24. Literature was an important source of information, but since not much literature focuses on station choice itself, some additional factors were brought up by 6 cyclists that have experience with station choice.

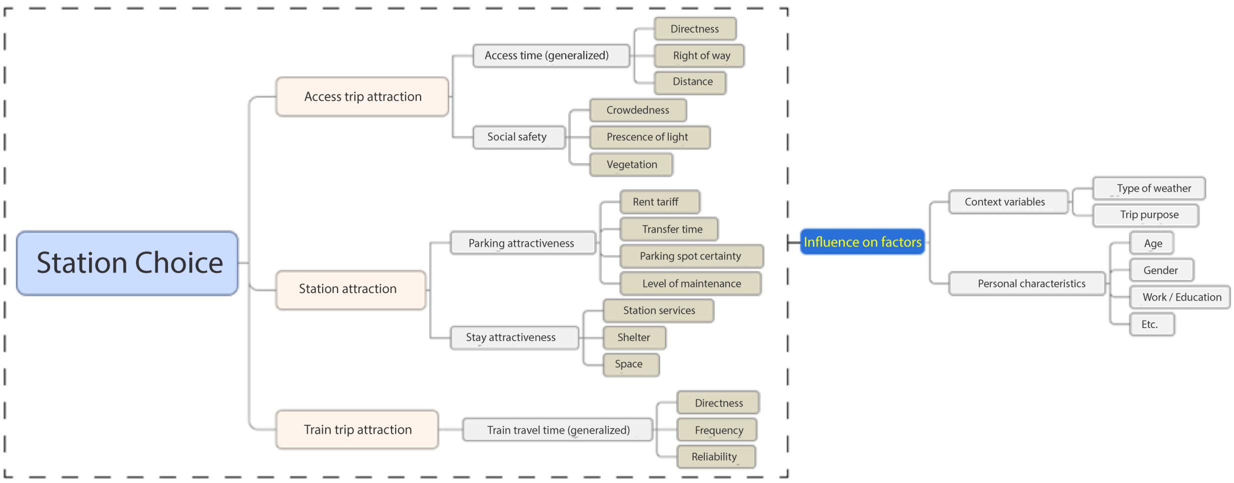

Figure 24 - Factors that influence station choice

The factors don't have an equal influence on station choice. To acquire knowledge about this, all factors were ranked. The most influential factors are (starting at most): total travel time, direct trip (train), bicycle travel time, parking to platform time, costs of bicycle parking, frequency (train), reliability (train). This is supported by the theory of satisfiers and dissatisfiers for a journey. All factors here are dissatisfiers which supports them being most influential.

Total travel time is the most important factor. However, bicycle travel time and parking to platform time are also in the list, which shows that not all time components are valued equally. The choice experiment gave more insight in the separate factors. The experiment revealed the interrelation between the most important factors that influence station choice. This made it possible to calculate the interchangeability of those factors. For example, how one minute of train time compares to one minute of bike time.

Parking price has a monetary value. This can be used to calculate the value of time or willingness to pay within the context of station choice. Furthermore, this is an understandable unit to show interchangeability. Those values are:

Bike time:	€0.11 per minute	Time to Park:	€0.08 per minute
Train time:	€0.08 per minute	Transfer:	€0.60 per transfer

This is not the only way to compare the impact of the factors. In fact, any unit of the factors (€, minute or number) can be used to compare the impact of the factors. Figure 25 shows what one minute of bike time is equal to and what one transfer is equal to. This shows that someone is willing to accept 4 minutes of extra train time for every 3 minutes of bike time saved. It also shows that someone is accepting 7.5 extra minutes of train time to prevent a transfer between trains. This means that a transfer to an intercity is only valuable if at least 7.5 minutes are saved. The outcomes seem valid, however they are in the lower bound of the range that literature shows.

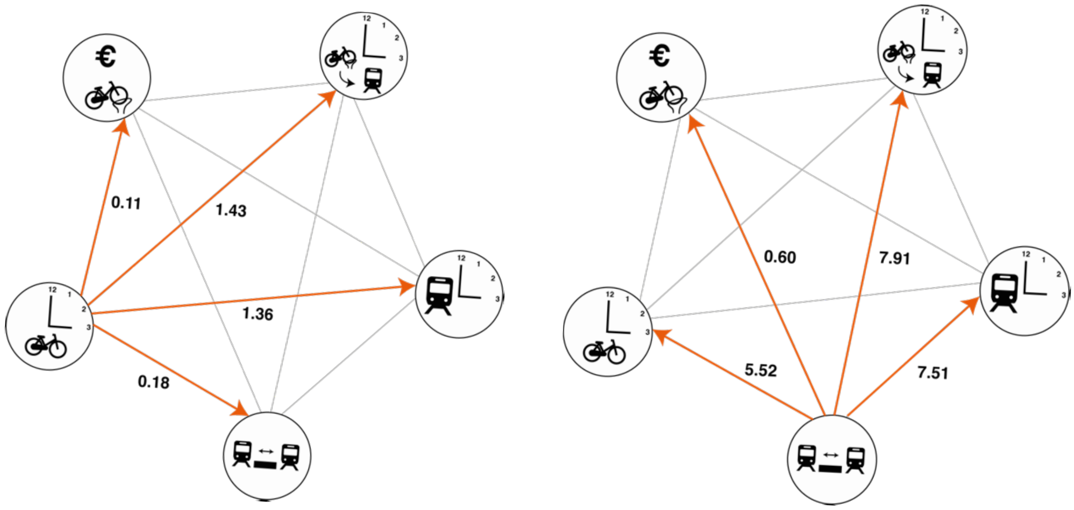

Figure 25 - Interrelation pentagon, bike time as a base (left), transfer as a base (right)

The choice experiment created new knowledge that is valuable for both science and practice. The connection to practice was made after the choice experiment. The goal was to find measures that can influence station choice.

That factors have an impact on the attractiveness of a station is now proven. Possible measures therefore should influence those factors. A subdivision can be made between the access part, at the station and train trip. A combination that influences all factors is also a possibility. Table 17 shows an overview of the possible measures and difficulties that may occur when implementing them. The set of measures was acquired by executing a set of semi-structured interviews with stakeholders and experts. It was not possible to show the real impact that those measures would have on station choice. The reason is that the outcomes are generic and the real impact is context specific. However, the last column indicates which measures have the most potential to be implemented. This is based on an assessment executed by the author.

Table 17 - Measures to influence station choice including difficulties and potential to implement (1 = most potential, 3 = least potential)

Solution category	Name	Difficulties	Potential
Access trip	Stretching routes	Financial, Technical	3
	Right of way	Political	2
At the station	Pricing	Behavioral, Political	1
	Pricing (reducing free time)	Behavioral, Political	1
	Rewarding	Financial, behavioral	1
	Parking close to platform	Financial, Technical	1
	Easy access and fast lanes	Financial	2
Train trip	Change schedule	Political, Technical	2
	Increase speed	Financial	3
Combination	Increase information	Financial, technical	2

With a case study, the implementation of a measure was illustrated. The case (the choice between the stations Amsterdam RAI and Amsterdam Zuid) showed that by taking measures the attractiveness of Amsterdam Zuid can be decreased compared to Amsterdam RAI. This results in less parking pressure at Amsterdam Zuid. The measures that were taken here are: parking costs being increased at Amsterdam Zuid and train time between Amsterdam RAI and Almere being decreased. The case study was not extensive enough to give estimates of the number of travelers that will change behavior. However, because Amsterdam RAI became more attractive it is likely that travelers will change their station choice.

The research question: *on what factors do 'bicycle-train' travelers base their station choice when accessing the railway network, how are those factors related and what are measures to influence this choice based on those factors?* is hereby answered. Now there is an overview of the factors, their strength in their relation is determined and the possibilities for influencing station choice are pointed out.

There are limitations to the methods used in this study, like the number of respondents, but as pointed out before that will be discussed in the reflection. This will lead to recommendations

This two-stage study created valuable insights on station choice fundamentals and presented measures to influence station choice. Influencing station choice could become an innovative solution for parking problems at railway stations. It shows that influencing station choice has potential. The presented set of measures can help with the reclamation of this potential.

9 Discussion

This chapter puts the outcomes of this study in a broader discussion. The study is executed with the assumption that time has a negative value. This is reasonable since people could have used travel time to be productive. This is a theory on which influencing behavior in the mobility field is built on. This however, is not the only way to describe behavior of people. There is still a lot of discussion about how to describe the world. Te Brömmelstroet (2014) warns for accepting the value of time theory as a universal truth. It could lead to "perversity and jeopardy in behavioral change campaigns" (Te Brömmelstroet, 2014). Behavioral change could lead to unintended effects because people that where already doing the right thing start changing their behavior too (in the wrong way). In the example of influencing station choice this could happen when people that already used the right station get frustrated because they are not being rewarded for already doing the right thing. This doesn't mean that rewarding people is a wrong approach, but this risk of moral hazard should be considered when implementing rewarding as a measure.

As mentioned before, the value of time theory assumes that travel time costs money. In reality it is the question whether this is always true. When looking at the outcomes of the study, time definitely has a value, but in this study people were forced to choose between 5 factors. In reality there are a lot more. Falsification of the hypothesis that travel time has price is possible by finding examples where this might not be the case. Think about people that stand still on the road during rush hour. TNO (2012) found out that some people see the period of standing in a traffic jam as relaxing. Relaxing is something positive and therefore generates value. This example shows that travel time might also have a positive value.

Next to the personal effect of longer travel times, there might also be societal benefits. One of those benefits is exposure to diversity (Te Brömmelstroet, Nikolaeva, Glaser, Nicolaisen, & Chan, 2017). This is something that is very hard to monetize, but that doesn't mean that there is no positive effect. This exposure to diversity shows to people how the world operates, how society operates and how people (are supposed to) interact. The value of interacting with people is also acknowledged in the 5xE framework (Van der Bijl, Maartens, & Van Oort, 2016) that was already mentioned in section 1.2, as one of the E's stands for equity. In the example of influencing station choice, the harmful effect on this 'exposure to diversity' could be a shorter travel time, since this reduces the exposure to diversity.

The remarks are not made to reduce the value of this study, they are mainly mentioned to show that there is not one way to describe the world. The critique there is against the value of time and choice theories is valuable. However most of those critiques don't come up with a better solution to quantitatively describe the impact of value of time on a choice. It is the best available to describe the effect of measures. The value of the critique is that it forces policymakers to think further than only the outcomes of choice experiments.

10 Reflection

This study used several methods. The reasons to use those methods were extensively mentioned. Nevertheless, those methods have certain limitations and weaknesses. In this chapter their limitations are discussed. Which also forms a basis for recommendations for future research. First the fundamental part is discussed followed by the policy part.

10.1 Fundamental stage

For the generation of the factors that influence station choice literature was used. Since literature was not completely focused on station choice, also six experienced bicycle train travelers were asked to come up with the factors they considered influential. This is a rather low number of respondents, and this might have the effect that not all factors are mentioned. However, since this phase was explorative and mainly had the purpose to prepare for the choice experiment the outcomes were sufficient.

The factors were not only mapped but they were also ranked. This was mainly founded on a ranking that was done by 20 respondents. The purpose here was to select which factors should be included in the choice experiment. For that purpose, a higher number of respondents was not possible within the available amount of time. 20 is not much when representing a population of over a hundred thousand. At the same time the mean absolute deviation is only 1.5 which indicates that the respondents are quite consistent in their ranking. This strengthens the outcomes. To support the outcomes, they were compared with the theory of satisfiers and dissatisfiers (Van Hagen, Peek, & Kieft, 2000), this supported the factors being most influential.

The choice experiment had the aim to give insight in the impact of the five most important factors that play a role in the station choice. Each of those factors was quantified. This was a generic study. Which means that choice situations are presented that are not based on a case but are purely designed for research purposes. This minimizes the context and makes the outcomes generic. Respondents will always imagine some context but this is reduced by explaining a minimum of context (e.g. dry day). The backside of this is that it cannot show the true potential of implementation of measures on a real case. The reason for this is that context plays an important role in determining whether a measure will work. This is not so much a weakness of the method itself but more a limitation for the use of the outcomes in practice.

The validation of the outcomes showed that the acquired values of time (VOT) are within the range of VOTs found in previous studies. However, the outcomes were at the bottom of this range. The VOT in this research is acquired within the context of cyclists. That means that there is no competition from other modes. A lack of competition leads to higher prices and thus higher values. It is important to keep that in mind when using the outcomes.

269 respondents cooperated in the experiment. This led to statistically significant outcomes at the 1% level. Although this seems very strong there are also some weaknesses in the dataset. The respondents have a relatively high income; this might have resulted in an overestimation of the VOT. At the same time the age distribution is not completely in line with the one of train users. This might have resulted in an underestimation of VOT. It is possible that both effects compensate for each other. However, this weakness doesn't mean that the outcomes are useless, the validation proved that. Moreover, it was also shown that the high number of

highly educated respondents is in line with the user group of the bicycle train mode. Therefore, the outcomes give a valuable direction.

In the analysis, no selection was made to check whether respondents had an actual choice between stations in their town of residence. This could be of impact because some would be less familiar with a choice. It was not possible within the limited time of this study to check for this. It might have had an impact on the outcomes, however since most respondents live in cities that do have more than one station this impact is probably limited.

10.2 Policy stage

To generate policy, interviews were held with stakeholders and experts. The purpose was to generate measures that can influence station choice. Interviewees were not directly linked within the text. This had a negative impact on the repeatability. However, there was a good reason for this approach. By stating this condition before the interviews, the respondents could be more open. Since it could have been the case that the parties some respondents represent, have certain contradicting interests. For this stage is was very important that everyone could be open, and that there were no stories that remain untold. Furthermore, the purpose was to create as many measures with all their pros and cons, stating the respondents in the text would not have added to this goal.

The measures were rated on impact and effort. This was mainly done to indicate which measures are promising. The rating was executed by the author and based on the experience in the field that was required over the last months. The valuation of one person is not very strong, a higher number of experts could improve the validity of this valuation. However, the purpose to give readers an indication of the impact and effort of measures is fulfilled.

At the end of the thesis it is shown what happens when measures are implemented. The effect of the implemented measures is mainly viewed from a single user perspective; how can the behavior of a rational person be changed. However, irrationality plays a role. When implementing measures this is one of the main aspects that determines the success of a measure. After all, the outcomes of the choice experiment were acquired with forced rationality. Something that doesn't often take place in most minds. Therefore, it would have been valuable to incorporate this aspect into the calculation shown in the illustration. This would have required a study on its own. Which was not possible within the available amount of time. Because it is a basic calculation, it is a very understandable way to show the possibilities of this study, which is in line with the purpose of the sub question it answered

11 Recommendations

The recommendations can be subdivided in two types of recommendations. First the scientific recommendations for future research that are based upon the insights coming from the reflection. Second, recommendations for the implementation of measures that could influence station choice with the aim of spreading parking pressure.

11.1 Scientific recommendations

This study used a relatively limited method to explore the factors. However, mapping all the factors that influence station choice can be very valuable for science (and practice). An empirical study could retrieve those factors from travelers. This leads to the following recommendation:

Explore all factors that influence station choice in an empirical study

This study mainly focused on the five most important factors that influence station choice. There are numerous factors that influence this choice. In a larger study, it is possible to include more factors in the choice experiment. Using an existing panel would be a practical option. It also has the advantage that it often has a more diverse composition of respondents. This would result in a high generalizability. This leads to the following recommendation:

Include more factors in future research on this subject and use a panel to have a larger number of respondents with a more diverse composition.

The risk of including too many factors in an experiment is that the influence of marginal factors is overestimated. Therefore, it would also be valuable to combine the knowledge that is acquired in studies like this one and give a palette of factors. Because methodologies differ it is difficult to give parameter estimates for all those factors, however a qualitative meta-analysis could be a good tool for this. This leads to the following recommendation:

Execute a meta-analysis on different studies of factors that influence the attractiveness of a station (parking).

This study didn't select the respondents on whether they had a choice in real life. It just assumed that everyone is able to weigh the different factors. In reality respondents that are familiar with making choices might weigh them differently. It would be wise to set up a list of zip codes were people do have a choice. This list can then be used on this dataset, or on a new panel dataset. This leads to the following recommendation:

Set up a list of zip codes where a station choice is possible, match this list with a dataset and analyze the data with the selected group of respondents

A set of possible measures to influence station choice was created. They were rated on two scales (impact and 'effort to implement'). However, this was only done by the author as an indication. To show the true potential of the measures it needs more support. An option is to use multiple experts to rate the measures This leads to the following recommendation:

Let multiple experts rate the measures to get a stronger view on the impact of measures and the effort that is needed to implement them.

11.2 Policy recommendations

This study was commissioned by the ministry of Infrastructure and Environment to find innovative solutions for parking pressure around stations. One of those potential solutions is spreading the parking pressure. Because it is impossible to force people to use another station behavior should be influenced. This study shows that travelers value factors that determine their station choice differently. This knowledge is used in the policy part of this study to come up with a set of measures that can influence station choice. The background is that it is valuable to make stations that currently have over capacity more attractive. By doing this, travelers are pulled away from the less attractive stations.

One of the most potential measures to implement is pricing of the overcrowded parking or rewarding for the use of the parking that is underused. This study states that there are risks to this pricing policy (e.g. mode change). Because those risks can best be quantified in a real case it is advised to start a pilot project were pricing measures are used. This should be a location where the potential risks can be controlled. In a later stage, other measures can be added to this pilot to evaluate their impact. This leads to the following recommendation:

Start a pilot to spread parking pressure by pricing measures, and analyze the effects. The risks of the measures should be monitored and if necessary measures can be changed or added.

Parking to platform time has shown to be of influence to the valuation of a station. The question however is whether this can be used to influence station choice. In general, the less crowded station already has shorter parking times. Therefore, it is hard to use this knowledge to influence the choice. However, this is something that should be taken into account when designing new stations. This leads to the following recommendation:

Design any new overflow station[4] in such a way that the parking to platform distance is minimized.

Many of the parking problems occur at larger stations. Those stations are often crowded because of the number of trains and connections. In a way the train schedule therefore creates parking pressure at those stations. This is not only problematic for parking's but (on the long term) the stations also reach their transfer capacity. Coping with this problem requires a new view to scheduling trains. In the Randstad area it might be necessary for multiple reasons to let intercity trains stop at more stations. This will automatically influence station choice and therefore spread parking pressure. A way to let trains stop at more stations could be a return to the old 3-train system (local, regional and intercity trains). The experience with three train systems can be used to create an improved version. Changing schedules is something that might be too big for just solving the parking problem, however as mentioned there is more than one reason to reconsider the current schedule. This leads to the following recommendation:

To spread pressure over more stations, making changes to the train schedule is a measure that has a lot of impact. Therefore, it is advised to reschedule the trains with a focus on more stops.

[4] An overflow station is defined as a station close to an intercity station that has the potential to pull travellers from that intercity station.

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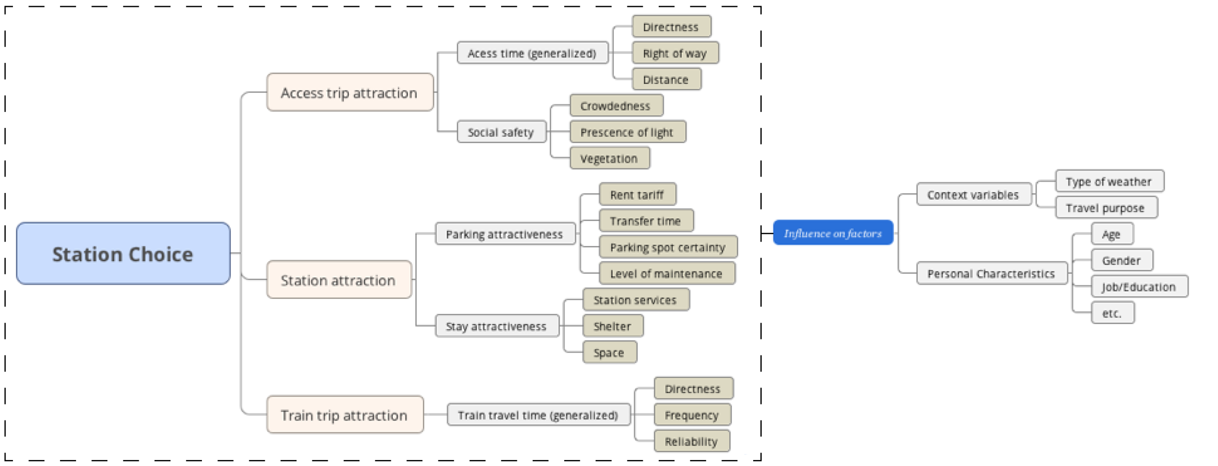
Appendix A: Building up the factor tree

In the explorative phase a factor tree is made to show the dependencies of the different factors that were indicated. This factor tree is set up by the author, this table shows how the factors in the tree are linked to the ones in the text.



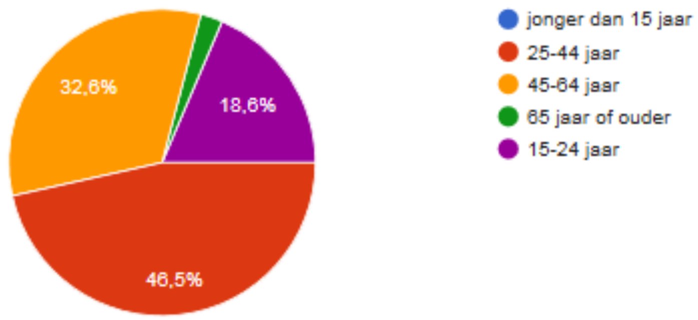
Level 1	**Level 2**	**Level 3**	**Factors in text**
Factors that impact station choice	Access time (generalized)	Directness	Directness
		Right of way	Right of way Design of infrastructure Separate infrastructure
		Distance	Costs of time
	Social safety	Crowdedness	Design of infrastructure Number of other users Obstacles Parked cars
		Social safety	
		Presence of light	Presence of light
		Vegetation	Vegetation
	Parking attractiveness	Parking price	Out of pocket costs Parking price
		Transfer time	Transfer time
		Parking spot certainty	The chance of finding a parking spot
		Level of maintenance	Level of maintenance
	Stay attractiveness	Station service	Presence (availability) of charging points Station services
		Shelter	Shelter
		Space	Space
	Train travel time (generalized)	Directness	Directness
		Frequency	Frequency
		Reliability	Reliability
Influence impact of factors	Context variables	Type of weather	Type of weather
		Travel purpose	Travel purpose
	Personal characteristics	Age	
		Gender	
		Job/education	
		Etc.	

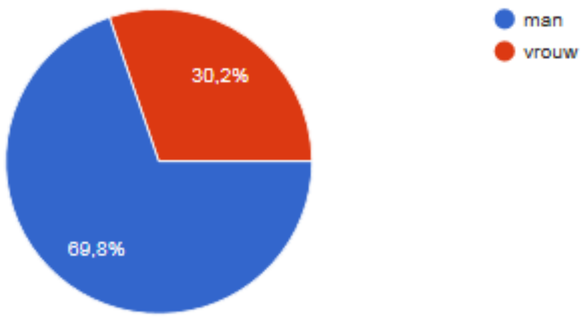
Appendix B: Additional information about pilot study

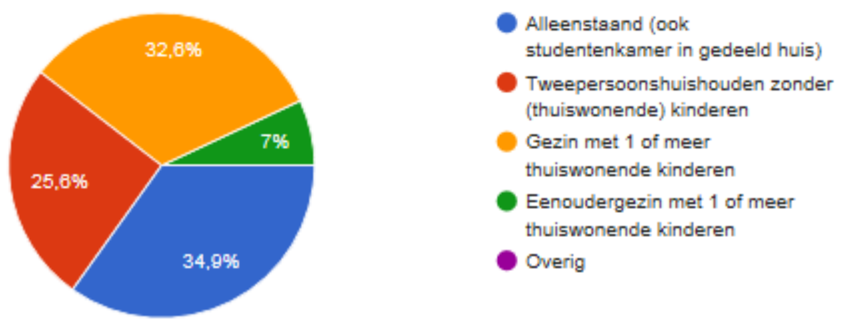
NGENE syntax:

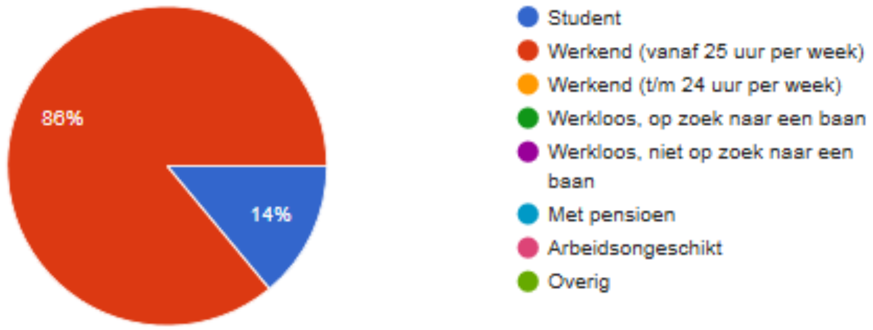
```
? This will generate a fractional factorial design
;alts = alt1, alt2
;rows = 12
;orth = ood
;model:
U(alt1) = b1 * A[5,10,15] + b2 * B[25, 35, 45] + b3 * C[1,3,5] +b4 * D[0,0.5,1] + b5 * E[0,1]
U(alt2) = b1 * A + b2 * B + b3 * C + b4 * D + b5 * E $
```

The questionnaire was filled in by 43 persons, some personal characteristics of the respondents are shown below:









The outcomes were analyzed using the following utility function:

$ALTi = \beta_{biketime} * Biketime_i + \beta_{transfertime} * Transfertime_i + \beta_{traintime} * traintime_i + \beta_{price} * Price_i + \beta_{direct} * Direct_i$

This utility function is incorporated in the following syntax:

```
[Choice]
CHOICE

[Beta]
B_BIKETIME          0    -10000    10000   0
B_TRANSFERTIME      0    -10000    10000   0
B_TRAINTIME         0    -10000    10000   0
B_PRICE             0    -10000    10000   0
B_DIRECT            0    -10000    10000   0

[Utilities]
1  alt1  av1   $NONE
2  alt2  av2   $NONE

[GeneralizedUtilities]
1 B_BIKETIME * BTA + B_TRANSFERTIME * TFTA + B_TRAINTIME * TRTA + B_PRICE * PA + B_DIRECT * DA
2 B_BIKETIME * BTB + B_TRANSFERTIME * TFTB + B_TRAINTIME * TRTB + B_PRICE * PB + B_DIRECT * DB

[PanelData]
ID
ZERO_SIGMA

[Expressions]
av1 = 1
av2 = 1

[Model]
$MNL
```

The outcomes of the model are the following:

Name	Value	Std err	t-test	p-value
B_BIKETIME	-0.124	0.0168	-7.39	0.00
B_DIRECT	-0.732	0.0991	-7.39	0.00
B_PRICE	-1.32	0.156	-8.45	0.00
B_TRAINTIME	-0.103	0.00825	-12.44	0.00
B_TRANSFERTIME	-0.102	0.0350	-2.92	0.00

Appendix C: Survey

Enquête stationskeuze, op de fiets naar het treinstation.
Voor mijn afstudeeronderzoek aan de TU Delft naar de onderdelen die een rol spelen bij de keuze voor een treinstation heb ik de volgende vragenlijst opgesteld. Het is de bedoeling dat de uitkomsten bij gaan dragen aan het oplossen van parkeerproblemen bij veel Nederlandse stations. Door het invullen van deze vragenlijst draagt u daar aan bij.

De vragenlijst bestaat uit drie onderdelen. Om te beginnen worden wat algemene vragen (persoonskenmerken etc.) gesteld, vervolgens worden 9 keuzes voorgelegd. Tot slot zijn er nog een aantal afsluitende vragen.

Het invullen van deze vragenlijst zal ongeveer 5-7 minuten duren. Invullen van de vragenlijst is anoniem. Veel dank voor de medewerking.

Mocht u vragen hebben kunt u contact met mij opnemen via j.f.p.vanmil@student.tudelft.nl

Persoonskenmerken

1 **Wat is uw leeftijd?** *Markeer slechts één ovaal.*

jonger dan 15 jaar
16-24 jaar
25-44 jaar
45-64 jaar
65 jaar of ouder

2 **Wat is uw geslacht?** *Markeer slechts één ovaal.*

man
vrouw

3 **Wat is uw hoogst voltooide opleiding** *Markeer slechts één ovaal.*

Basisschool
VMBO/MAVO
HAVO
VWO
MBO
HBO
Bachelor WO
Master WO (Doctoraal)
PhD
Anders:

4 **Wat is uw huishoudenssamenstelling** *Markeer slechts één ovaal.*

Alleenstaand (ook studentenkamer in gedeeld huis)
Tweepersoonshuishouden zonder (thuiswonende) kinderen
Gezin met 1 of meer thuiswonende kinderen
Eenoudergezin met 1 of meer thuiswonende kinderen
Anders:

5 **Wat is uw jaarlijks bruto inkomen? (in geval van samenwonen uw gezamenlijk inkomen)**
Markeer slechts één ovaal.

Geen inkomen
Minder dan €10.000

€10.000 - €20.000
€20.000 - €30.000
€30.000 - €40.000
€40.000 - €50.000
Meer dan €50.000
Zeg ik liever niet/Weet ik niet

6 **Wat is (voornamelijk) uw arbeidssituatie?** *Markeer slechts één ovaal.*

Student
Werkend (vanaf 25 uur per week)
Werkend (t/m 24 uur per week)
Werkloos, op zoek naar een baan
Werkloos, niet op zoek naar een baan
Met pensioen
Arbeidsongeschikt
Anders:

7 **Hoe vaak reist u met de trein?** *Markeer slechts één ovaal.*

Meer dan 3 keer per week
1 tot 3 keer per week
een paar (1-4) keer per maand
Zelden
Nooit

8 **Wat is meestal het doel van uw treinreis?** *Markeer slechts één ovaal.*

Voornamelijk school/studie
Voornamelijk werk
Voornamelijk visite (bijv. familiebezoek), recreatie en vrije tijd
Beide even vaak

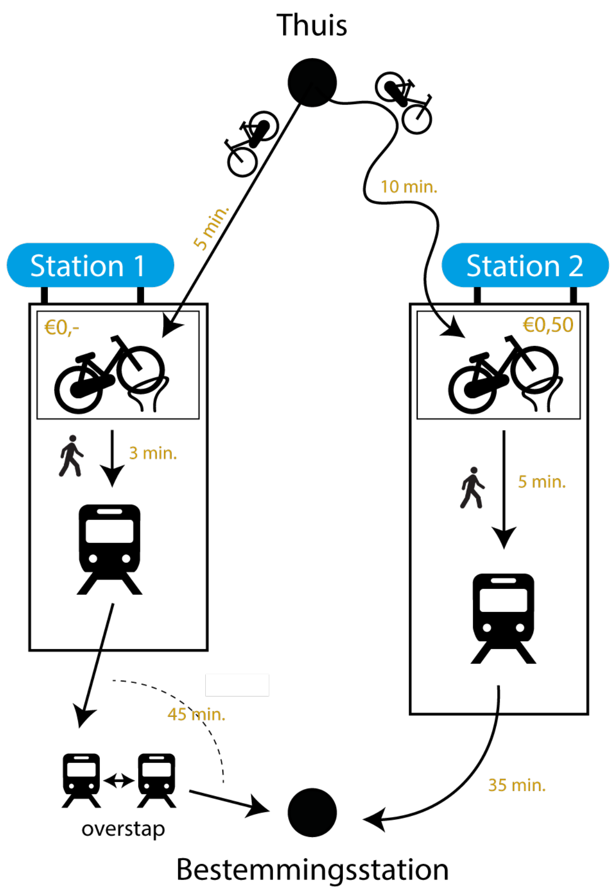
9 **Welk vervoermiddel gebruikt u vooral om vanuit uw huis bij het station te komen?** *Markeer slechts één ovaal.*

Fiets
Auto
Lopend
OV (Tram, Bus, Metro)
Anders:

10 **Wat is uw postcode? (inclusief letters)**

11 **Keuzesituaties** Hieronder volgen 9 vragen, telkens kunt u kiezen tussen twee station om naartoe te fietsen. Vanaf het
station reist u met de trein verder naar uw eindbestemming. Ieder station heeft zijn eigen karakteristieken. De stations onderscheiden zich van elkaar op de tijd die nodig is om naar het station te fietsen (fietstijd), de kosten om je fiets te stallen (stallingskosten), de tijd die nodig is om je fiets te stallen en bij het perron te komen (tijd naar perron), of er een overstap in je treinreis zit, en hoe lang de treinreis naar je eindstation duurt (duur treinreis). Het maakt bij deze keuzes niet uit of je deze reizen ook in werkelijkheid maakt. Stel je simpelweg voor wat je zou doen als je voor deze keuzes gesteld zou worden en kies het station dat jou het beste lijkt. Denk daarbij wel aan een dag zonder regen.

De onderstaande afbeelding laat zien hoe zo'n keuze er uit zou kunnen zien (met de verschillende onderdelen die meespelen). Bij het ene station is het ene onderdeel aantrekkelijker en bij het andere station het andere onderdeel. Bij de vragen die voorgelegd worden zijn alleen de onderdelen overzichtelijk weergeven.



12 **Keuze 1**

Station 1		Station 2	
Fietstijd:	10 minuten	Fietstijd:	10 minuten
Stallingskosten:	€0,50	Stallingskosten:	€0,50
Tijd naar perron:	5 minuten	Tijd naar perron:	1 minuut
Overstap in treinreis:	Nee	Overstap in treinreis:	Ja
Duur treinreis:	25 minuten	Duur treinreis:	35 minuten

Markeer slechts één ovaal.

Station 1
Station 2

13 **Keuze 2**

Station 1		Station 2	
Fietstijd:	5 minuten	Fietstijd:	15 minuten
Stallingskosten:	€0,-	Stallingskosten:	€1,-
Tijd naar perron:	1 minuut	Tijd naar perron:	5 minuten
Overstap in treinreis:	Ja	Overstap in treinreis:	Nee
Duur treinreis:	45 minuten	Duur treinreis:	25 minuten

Markeer slechts één ovaal.

Station 1
Station 2

14 **Keuze 3**

Station 1		Station 2	
Fietstijd:	10 minuten	Fietstijd:	10 minuten
Stallingskosten:	€0,-	Stallingskosten:	€1,-
Tijd naar perron:	5 minuten	Tijd naar perron:	1 minuut
Overstap in treinreis:	Nee	Overstap in treinreis:	Nee
Duur treinreis:	45 minuten	Duur treinreis:	25 minuten

Markeer slechts één ovaal.

Station 1
Station 2

15 **Keuze 4**

Station 1		Station 2	
Fietstijd:	15 minuten	Fietstijd:	5 minuten
Stallingskosten:	€0,50	Stallingskosten:	€0,50
Tijd naar perron:	1 minuut	Tijd naar perron:	5 minuten
Overstap in treinreis:	Ja	Overstap in treinreis:	Nee
Duur treinreis:	25 minuten	Duur treinreis:	45 minuten

Markeer slechts één ovaal.

Station 1
Station 2

16 **Keuze 5**

Station 1		Station 2	
Fietstijd:	15 minuten	Fietstijd:	5 minuten
Stallingskosten:	€0,50	Stallingskosten:	€0,50,-
Tijd naar perron:	3 minuten	Tijd naar perron:	3 minuten
Overstap in treinreis:	Ja	Overstap in treinreis:	Nee
Duur treinreis:	35 minuten	Duur treinreis:	45 minuten

Markeer slechts één ovaal.

Station 1
Station 2

17 **Keuze 6**

Station 1		Station 2	
Fietstijd:	10 minuten	Fietstijd:	10 minuten
Stallingskosten:	€1,-	Stallingskosten:	€0,-
Tijd naar perron:	3 minuten	Tijd naar perron:	3 minuten
Overstap in treinreis:	Nee	Overstap in treinreis:	Ja
Duur treinreis:	35 minuten	Duur treinreis:	25 minuten

Markeer slechts één ovaal.

Station 1
Station 2

18 **Keuze 7**

Station 1		Station 2	
Fietstijd:	5 minuten	Fietstijd:	15 minuten
Stallingskosten:	€1,-	Stallingskosten:	€0,-
Tijd naar perron:	1 minuut	Tijd naar perron:	5 minuten
Overstap in treinreis:	Nee	Overstap in treinreis:	Ja
Duur treinreis:	45 minuten	Duur treinreis:	35 minuten

Markeer slechts één ovaal.

Station 1
Station 2

19 **Keuze 8**

Station 1		Station 2	
Fietstijd:	15 minuten	Fietstijd:	5 minuten
Stallingskosten:	€0,-	Stallingskosten:	€1,-
Tijd naar perron:	3 minuten	Tijd naar perron:	3 minuten
Overstap in treinreis:	Nee	Overstap in treinreis:	Ja
Duur treinreis:	35 minuten	Duur treinreis:	35 minuten

Markeer slechts één ovaal.

Station 1
Station 2

20 **Keuze 9**

Station 1		Station 2	
Fietstijd:	5 minuten	Fietstijd:	15 minuten
Stallingskosten:	€1,-	Stallingskosten:	€0,-
Tijd naar perron:	5 minuten	Tijd naar perron:	1 minuten
Overstap in treinreis:	Ja	Overstap in treinreis:	Nee
Duur treinreis:	25 minuten	Duur treinreis:	45 minuten

Markeer slechts één ovaal.

Station 1
Station 2

21 **Afsluitende vragen**

In de voorgaande keuzes was steeds informatie beschikbaar. Welk station zou u kiezen als je niet alle informatie (fietstijd, prijs etc.) paraat zou hebben? *Markeer slechts één ovaal.*

Het station wat (gevoelsmatig) het dichtstbij is.
Het intercitystation dat (gevoelsmatig) het dichtstbij is.
Informatie opzoeken en daarmee de keuze bepalen.
Anders:

22 **De keuzes bestonden steeds uit drie tijdsonderdelen (fietstijd, looptijd naar perron en treintijd), heb je bij het maken van de keuzes vooral naar de totale tijd gekeken of naar de tijden apart?** *Markeer slechts één ovaal.*

Totaal
Afzonderlijke waardering

23 **Als het zou regenen zou de fietstijd in uw keuze dan van grotere invloed zijn geweest?** *Markeer slechts één ovaal.*

Gelijke invloed
Grotere invloed
Veel grotere invloed

24 **Op welke manier bent u bij deze vragenlijst terecht gekomen?** *Markeer slechts één ovaal.*

Gevraagd bij een treinstation
Via internet en/of social media
Via e-mail
Anders

25 **Vind u het leuk om geïnformeerd te worden over de uitkomsten van dit onderzoek? Laat dan hieronder uw e-mailadres achter. (Dit adres zal losgekoppeld worden van uw antwoorden.)**

Hartelijk dank voor het meewerken aan dit onderzoek.

Appendix D: Interviews

The interviews are set up by the following procedure (in Dutch):

Stap 0:
Gesprek starten, inleiding (+achtergrond onderzoek), voorstellen etc.

Stap 1:
Achtergrond onderzoek vertellen en uitleggen wat ik gedaan heb.

Stap 2:
Resultaten voorleggen, focus op uitkomst over de gehele groep vanwege beperkte tijd.

Stap 3 – Reactie op resultaten:
Vraag: Wat vindt u van het onderzoek en lijken de uitkomsten u valide?

Stap 4 – Oplossingsmogelijkheden:
Vraag: Ziet u mogelijkheden deze uitkomsten te gebruiken om stationskeuze te beïnvloeden?
Vraag: Heeft u hier concrete ideeën voor?

Stap 5 – Waardering van de oplossingsmogelijkheden
Vraag: Welke voor en nadelen kennen de genoemde oplossingen volgens u?

Stap 6 – waardering van andere oplossingsmogelijkheden, voorleggen verschillende eerder gehoorde oplossingsrichtingen (neemt toe naarmate interviewfase vordert, alleen uitvoeren wanneer er voldoende tijd is)
Vraag: Welke voor en nadelen kennen de genoemde oplossingen volgens u?

Stap 7 – Afsluiten
Vraag: Hoe ziet u de kans van beïnvloeding van stationskeuze t.o.v. meer conventionele oplossingen?
Vraag: Kent u nog mensen waarvan u zou aanraden om daarmee te praten

The interviews are analyzed by coding the reports in categories. The codes used are shown below:

- Validation
  - VOT
  - Characteristics
  - Other
- Measures
  - Access trip
    - Reducing bike time
      - Stretching routes
      - Right of way
  - At station
    - Reduce time to park
      - Parking close to platform

            - Easy access and fast lanes
        - Pricing
            - Rewarding
            - Pricing
            - Pricing (reducing free time)
    - Train
        - Reduce train time (increase speed)
        - Change schedule (increase nr. of stations)
    - Information

The respondents are:

Organization	Job title	Name
NS Reizigers	Transport researcher	Mats Verschuren
NS Stations	Chainmanager NS stations	Kees Miedema
ProRail	Transport researcher	Paul Siderius
Ministerie I&M/APPM	Consultant bicycle I&M	Erik Tetteroo
Ministerie I&M/KIM	Researcher	Lucas Harms
Gemeente Amsterdam	Policy officer bicycle	Ria Hilhorst
Vervoerregio Amsterdam	Policy officer bicycle	Martijn Sargentini
Fietsersbond	Policy influencer	Wim Bot
University of Amsterdam	Researcher	Marco te Brömmelstroet