Valuation of a transfer in a multimodal public transport trip

A stated preference research into the experienced disutility of a transfer between bus/tram/metro and train within the Netherlands

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UNIVERSITY OF TWENTE.

Rik Schakenbos

Master thesis

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UNIVERSITY OF TWENTE.

Preface

This report describes a research into the disutility of transfers between trains and bus, tram or metro. The research is conducted as the final project for the master programme Civil Engineering and Management at the University of Twente. The research is carried out for Dutch Railways (NS), where I spent the last 7 months working on this project.

During my research, I had a lot of support and help from several people. I would like to thank Sandra Nijënstein (NS), Lissy la Paix Puello (UT) and Karst Geurs (UT) for the extensive feedback sessions and their critical comments which helped me to improve my research. Furthermore, I wish to thank all the others at MOA for making me feel welcome and contributing to the nice time I had working at NS. I would also like to thank Wouter Hermelink from Dinkel Systems, for his flexibility in the programming part of the web-based survey.

I hope that you will read this report with great interest and end up with new insights on multimodal transfers.

Rik Schakenbos
Utrecht, September 2014

Abstract

A web-based stated preference (SP) experiment is carried out to determine the transfer disutility of a transfer between bus/tram/metro (BTM) and train. The choice situations were described by the attributes BTM trip time, transfer time, in-train time, headway of the connecting mode, costs and station facilities. The experiment included choice situations between two BTM-train alternatives and choice situations between a BTM-train alternative and a train-train alternative. Based on the comparison of a BTM-train transfer with a train-train transfer, the BTM-train transfer disutility is estimated.

Respondents are recruited from the NS panel (N = 1064). To increase the realism of the experiment, the values for the BTM trip time, in-train time and costs were adaptive to the real values of a recent BTM-train trip as reported by the respondent. A general mixed logit error component model is estimated. Furthermore, sub models based on trip motive, travel frequency and trip stage are estimated. The estimation results offer information on the trade-off between the different attributes of a multimodal trip. The estimated parameters are within a reasonable range, compared with findings from literature.

A transfer between BTM and train with a transfer time of 8 minutes and a headway of the connecting mode of 15 minutes results in a transfer disutility of 29 minutes generalized travel time (GTT). The transfer disutility is highly dependent on transfer time and the headway of the connecting mode. Changing the transfer time from 8 minutes to 15 minutes increases the total transfer disutility to 39 – 51 minutes GTT. An increase of the headway of the connecting mode from 15 minutes to 30 minutes increases the GTT with 7 to 13 minutes. Only for recreational travelers an effect is found on station facilities. These travelers perceive a very large station positive with a value of 4 minutes GTT, compared to a medium or large station.

The egress time by bus is valued with a factor 1.4 compared to a minute in-train time. The access time by bus and the access/egress time by tram/metro are not found to be significantly different from in-train time. Values of time are estimated for different trip motives and incomes. The obtained values are in accordance with other value of time studies. In general, the most optimal transfer time is found to be 8 minutes, but differences are found between respondents and stations. High-frequent travelers prefer a transfer time of 6 minutes, while low-frequent travelers prefer a transfer time of 9 minutes.

The resulting values from this research can be used by NS to extend their route assignment model (for train trips) to BTM trips as well. Furthermore, insights into the preferences of different groups of travelers are provided. If the majority of travelers on a certain transfer have the same trip motive or travel frequency (for example work/business travelers during the morning peak hours), the transfer times can be adjusted to these types of travelers.

Summary

Motivation and research objective

Chain mobility is an increasingly important subjects among both public transport service providers and policy makers. A trip by public transport usually involves one or more transfers from one mode to another mode, which requires a substantial amount of effort from the traveler. Previous research by Dutch Railways already showed that large transfer penalties apply for transfers from train to train. Relatively little is known about the transfer disutility of transfers between bus/tram/metro (BTM) and train. The main research objective of this study is to determine the transfer disutility of a transfer between BTM and train. The influence of travel time, transfer time, headway, costs and station facilities on such a transfer will be quantified. Furthermore, the importance of these attributes will be differentiated for personal and trip characteristics.

According to literature, the disutility of a trip consists of three components: time, costs and effort. These three components consists of several attributes which all contribute to the total disutility of the trip. Effort is especially important for transfers and consists of elements like travel information, safety, uncertainty, station experience, reliability and station facilities. The valuation of the different components of transfer disutility differs for personal- and trip characteristics. Differences are identified in literature based on characteristics like trip motive, familiarity with the stations, travel frequency, gender, age, trip length, time of day and access/egress mode. The identified attributes and characteristics are combined into a conceptual model explaining the total transfer disutility.

Methodology

A web-based stated preference (SP) experiment is conducted where respondents received choice situations in which they indicated their preferred choice. Each respondent received 2 sets of 6 choice situations. The first set presents choice situations with a choice between two travel alternatives both involving a BTM access or egress trip, a transfer to or from train and a main trip by train. The second set presents choice situations in which one alternative is again a trip including BTM, train and a transfer between both. The other alternative is a trip where both the access/egress trip and the main trip are done by train. This way, a comparison can be made between a train-train transfer and a BTM-train transfer.

The SP experiment was part of a larger survey with additional questions. Respondents first had to describe a recent trip where BTM was used as access or egress mode. The type of trip which is described determines whether the respondent is presented choice situations with a transfer from BTM to train or from train to BTM. Furthermore, the specific BTM mode used by the respondent, is used in the choice experiment for this respondent as well. The alternatives are described by six attributes: access/egress trip time, transfer time, in-train time main trip, headway of the connecting mode, costs and station facilities. The attribute levels for access/egress trip time, in-train time and costs were adaptive to values experienced by the respondent in the reported trip. This way, the choice situations are close to the experience of the respondents, which yields more reliable results. The attribute level for headway of the connecting mode varied between 15, 20 and 30 minutes and five levels of transfer time were included (3, 5, 8, 11 and 15 minutes). Station facilities is included as a qualitative attribute describing the type of transfer station (medium, large or very large). Additional questions were included in the survey, asking respondents about socioeconomic characteristics like age, gender, income and working situation. Furthermore, the respondents assessed the transfer station of their recent trip on six different aspects.

Respondents are recruited from the NS panel, this is an online panel of train travelers who agreed to take part in research by NS on a regular basis. A total of 1145 respondents completed the full survey, of which 81 respondents are excluded, leading to a total net amount of 1064 respondents. Respondents are excluded based on a low survey completion time and unrealistic estimations of the trip time/costs. The sample was not fully representative for the NS population. Travelers with the trip motive school/study were heavily underrepresented. A weighting is applied to correct for unrepresentative distribution among trip motives. The

distribution of trip motives among the sample and the NS population, with the resulting weighting factors, is shown in Table 1.

Table 1: Distribution of trip motives compared to distribution among NS population

Trip motive sample	Amount of respondents	Percentage	Distribution among NS population (trips)	Weighting factor
Work/business	177	34%	45%	1.33
School/Study	39	8%	31%	3.97
Social	155	30%	11%	0.34
Recreational/other	144	28%	13%	0.50

The collected data is used to estimate discrete choice models, which are based on the random utility theory. This theory assumes that an individual choses an alternative which maximizes the utility of this individual. The estimated discrete choice models describe the total utility of an alternative and the contribution of separate attributes to this total utility. A large variety of model specifications is tested to achieve the final model specification. Since each respondent received 12 choice situations, the twelve choices within a respondent are correlated. An error component with a normal distribution, varying over people but being constant over choice situations for each person, is added to the utility functions to compensate for this panel effect.

A general model is estimated based on the data of all respondents. Furthermore, several sub models are estimated which only include data of respondents with specific characteristics. This way, the influence of these characteristics can be compared. Sub models are estimated based on access/egress trips, trip motive, travel frequency and BTM mode. The models based on trip motive, travel frequency and BTM mode are further distinguished into separate models by access or egress trips as well.

Results

The resulting models provide insights into the importance of the different attributes. Each attribute is expressed in "generalized travel time" (GTT). This means that all the utility values are converted to in-train time, making the results easier to interpret. The total transfer disutility turns out to be highly dependent on the transfer time. For a transfer time of 8 minutes, no difference is found between a BTM-train transfer and a train-train transfer. Both a smaller and a larger transfer time for a BTM-train transfer are awarded more negative. Small transfer times are disliked because the chance to miss the connection increases. Figure 1 shows the average transfer disutility for different transfer times and modes.

In general, the preferred transfer time for a BTM-train transfer is 8 minutes, but several differences are found between different groups. Travelers with trip motive work/business are more time-conscious and therefore perceive short transfer times better than travelers with the trip motive social or recreational. Furthermore, travelers of 60 years or older highly dislike a transfer time of 3 minutes. Differences in preferred transfer times between stations are found as well. The preferred transfer time on a station Utrecht Centraal is 9 minutes, compared to 5 minutes for station Amsterdam Amstel.

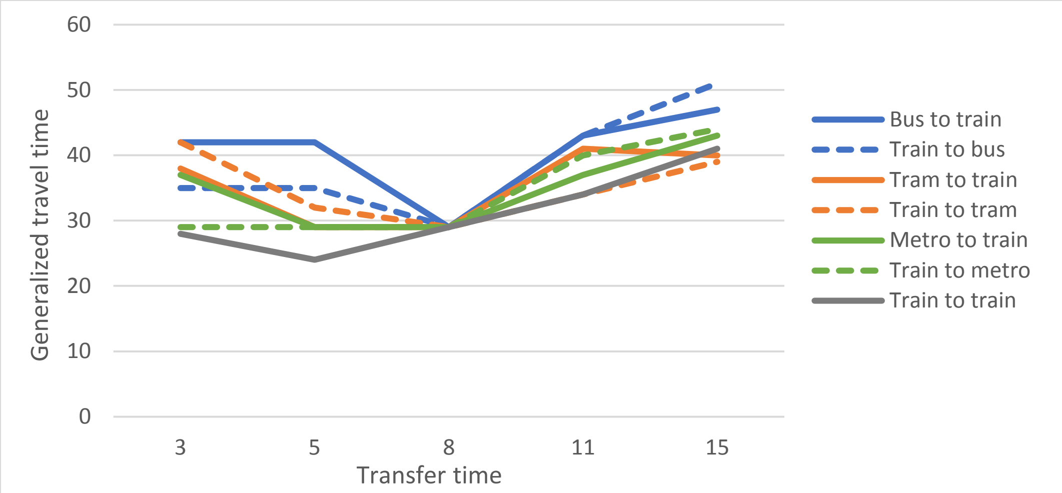


Figure 1: Transfer disutility per transfer time and mode

The valuation of the other attributes included in the choice experiment is discussed below.

BTM trip time

A minute in-vehicle BTM time is found to be significantly different from a minute in-train time for egress trips by bus. The egress time by bus is valued with a factor 1.4 compared to a minute in-train time. The access time by bus and the access/egress time by tram/metro are not found to be significantly different from in-train time. Travelers with a trip motive work/business award less disutility to access/egress time than travelers with other trip motives.

Costs

Based on the model estimation results, a value of time is calculated for the in-train time. The value of time expresses the amount of money a traveler is willing to pay to decrease the travel time with a certain amount. The value of time is found to be dependent on the combination of trip motive and income of the respondent. Travelers with trip motive work/business and high incomes have the highest values of time. A comparison is made between the obtained values of time per trip motive in this research and a state of the art value of time study within the Netherlands (Table 2). The obtained values in this research are within close range of the reference study, indicating a good validity of the model.

Table 2: Comparison of obtained values of time with state of the art value of time study (euro per person per hour)

Trip motive	Reference value	Obtained value current research
Work/business	11.50 – 15.50	13.22
Social	7.00	6.91
Recreational/other	7.00	6.06
General	9.25	8.03

Headway connecting mode

The headway of the connecting mode is important when a connecting is missed. In that case, it expresses the additional waiting time for the traveler. The results show that this headway is taken into consideration by travelers when they choose a travel alternative. Figure 2 shows the disutility which is awarded to a headway of 20 and 30 minutes, relative to a headway of 15 minutes. A distinction is made by access/egress and mode. These results are in accordance with values found in literature. It is assumed that the valuation of headway is more important for short transfer times (the chance to miss the connection is higher) but this relationship could not be established due to the design of the SP experiment which only considered main effects.

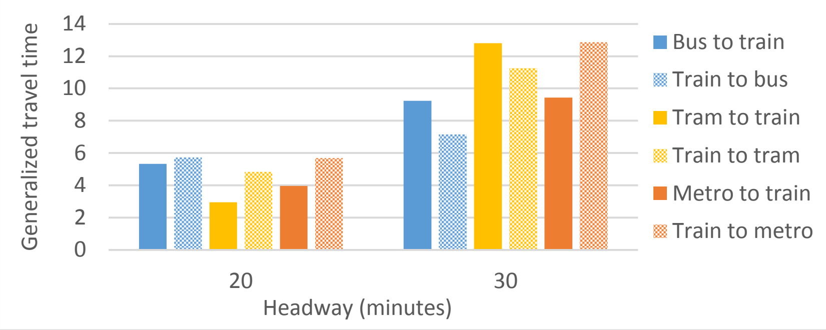


Figure 2: Valuation of headway of the connecting mode

Transfer station
Only small effects of station types are found in the models. For travelers with the trip motive recreational/other, a positive utility of 4 minutes generalized travel time is awarded when the transfer station is a very large station. This means that these travelers are willing to spend 4 minutes more travel time to have a transfer at such a station instead of a medium or large station. For the other trip motives the difference between station types was insignificant.

Respondents are asked to assess their last used transfer station. Large differences per stations are found in these assessments with strikingly high results for station Rotterdam Centraal, which is recently rebuilt. On a scale from 1 to 10, the general assessment for Rotterdam Centraal was 8.6, compared to 6.5 for Utrecht Centraal and 6.8 for Den Haag Centraal. A separate model estimation is performed for respondents who used Rotterdam Centraal and Den Haag Centraal in their reported trip. The amount of respondents was however too low to estimate reliable models.

Application

The results of this study can be used by NS in two ways. Firstly, the obtained values can be used to extend the used route assignment model (which currently only includes train) to BTM. A simplified procedure to determine the transfer disutility is proposed to make it feasible to implement the transfer disutility of BTM-train transfers in the route assignment model. If it is required only to use one value for the transfer disutility, the transfer disutility of an average BTM-train transfer (transfer time of 11 minutes and headway of 15 minutes) can be used. The transfer disutility for an average transfer is 43 minutes GTT for bus and 37 minutes GTT for tram/metro. Furthermore, a value of 1.28 minutes GTT is recommended to use as valuation for a minute in-vehicle time by bus. Since no significant differences are found between the valuation of in-vehicle time for tram and metro and in-train time, it is recommended to use a value of 1 minute GTT for a minute in-vehicle time by tram/metro.

Secondly, the results give insights into the preferences of the traveler. These insights can be used to meet the travelers' wishes in a transfer. It is shown that the preferred transfer time differs between travelers. Therefore, if the majority of travelers on a certain transfer have the same trip motive or travel frequency, the transfer times can be adjusted to these types of travelers. For example, during the morning peak hours, the majority of the respondents will be frequent work/business travelers, who prefer a transfer time of 6 minutes instead of the

Conclusions

The perceived transfer disutility is dependent on both transfer characteristics (transfer time, mode, headway connecting mode) and personal characteristics (travel frequency, trip motive, age). An average transfer has a transfer disutility of 43 minutes GTT for a transfer between bus and train and 37 minutes GTT for a transfer between tram/metro and train. The transfer disutility for an average transfer between trains is established in other research on 34 minutes GTT.

Although large differences are observed between the assessments of different stations, only for recreational travelers, a significant effect is found in the models. These travelers prefer a very large station over a medium/large station.

The transfer disutility is highly dependent on transfer time and the headway of the connecting mode. Changing the transfer time from 15 minutes to 8 minutes can decrease the total transfer disutility from 39 – 51 minutes GTT to 29 minutes GTT. It is recommended to coordinate the schedules of trains and BTM whenever this is possible.

Discussion

A few weaknesses are identified which could influence the validity of the results. First of all, the sample was not fully representative for the NS population. A weighting is applied on trip motive to correct for this unrepresentativeness. Furthermore, a positive bias towards BTM might occur since respondents are recruited when they indicated in a previous survey that they often use BTM as access or egress mode.

It should be noted that not all elements which influence the transfer disutility are taken into account in this research, due to practical limitations. Attributes like reliability or travel information can affect the transfer disutility as well. With a high level of reliability, small transfer times might be valued more positive. Furthermore, the attribute levels do not represent all the levels existing in reality. The headway of the connecting mode was at least 15 minutes in the SP experiment, while smaller headways can occur in reality. Interactions between attributes (for example transfer time and headway) are not estimated while it is expected that these interaction effects will occur. Finally, the use of SP data has some implications as well. Attribute levels are presented in a way that they can be evaluated rationally. In reality, the choice process might be less rational, which means that travelers might make other choices.

Table of contents

1. Introduction

The topic of this master thesis is the transfer disutility of transfers between bus/tram/metro (BTM) and train, which is further introduced in this chapter. The first section starts with the motivation for this subject. To narrow the scope of the study, the second section defines the objective and the research questions. The delimitation of the research is set out in section 1.3. The last section provides a brief overview of the research design.

1.1 Motivation

Chain mobility is an important subject among policy makers, both national and international. From a European perspective, this can be seen in different projects supported by the EU, for example in the SYNAPTIC program ('Synergy of New Advanced Public Transport Solutions Improving Connectivity in North West Europe'). This is an EU funded cluster of four North West European transport projects with the common objective to enhance the framework conditions for intermodality and seamless door-to-door journeys (SYNAPTIC, 2013). Another European example is INTERCONNECT which aims to make a better connection between short- and long-distance transport networks (Bak, Borkowski, & Pawlowska, 2012; Institute for Transport Studies, 2011).

The Dutch national government mentions chain mobility and door-to-door journeys as an important element in their national policy document about the Dutch infrastructure (Ministerie van Infrastructuur en Milieu, 2012). With the program "Innovative traveling from and to the station", the Dutch government supported 18 initiatives of innovative and smart solutions to make traveling from and to the station more efficient, easier and more fun (Arntzen & Lindeman, 2013).

From the service provider point of view there is also a growing interest in chain mobility and the connections to other modalities. This can be seen in one of the main strategy themes from Dutch Railways (NS): "we think from door to door" (NS, 2013). This door to door strategy is implemented in practice with systems like the public transport smart card and the NS Business card. Furthermore products and services as NS Zonetaxi, Greenwheels, NS scooter, OV-fiets, P+R facilities and bicycle storage facilities are mentioned as ways to increase the door to door journey for the traveler. Furthermore, research is currently conducted by NS and HTM into the coordination between the different public transport modalities (BTM and train). These examples show that NS is aware of the importance of access and egress trips for train journeys.

The importance of transfers in chain mobility is recognized in literature as well and research has already been conducted in this field. For example Guo (2003) states that a key component of chain mobility is easy and convenient transfers for the travelers. Research into the transfer between trains in a Dutch context is already available (Haarsman, 2012; de Keizer, Geurs, & Haarsman, 2012; de Keizer & Hofker, 2013). In international literature, several other studies exist about transfer resistance and values of time during a trip. However, the limitation of most studies is that they only consider transfers within one modality (Abrantes & Wardman, 2011; Guo, 2003; Guo & Wilson, 2011; Wardman, 2004; Wardman, Hine, & Stradling, 2001a). Another limitation is that knowledge about the relevant factors affecting the transfer resistance between different modalities is missing. Hine, Wardman, and Stradling (2003) state that "too many studies that have examined interchange have failed to separate the various components associated with interchange activity". Hoogendoorn-Lanser (2005) also states that "only a small number of transfer attributes is included in most travel choice models found in literature". Based on the current state of research, it can be concluded that a study into factors influencing the transfer resistance, especially in multimodal transfers will be a relevant research topic which will add valuable knowledge to the general ideas about transfers.

This research will focus on transfer resistance between access- or egress modes and trains. The three largest access- and egress modes for train trips in the Netherlands are walking, cycling and BTM. It is not feasible to include all access- and egress modalities in this study. Therefore, this study will focus on BTM. This choice is made because it is the most complex transfer, it can involve multiple public transport companies and the traveler has less control on the transfer compared to walking and cycling. Furthermore, NS recently obtained a share of 49% in the public transport company of the Hague (HTM). Therefore it is very interesting for NS to gain more knowledge on this type of transfer.

A practical application of the results of this research for NS is the expansion of the used route assignment model. NS currently works with the model VISUM to model route choice behavior of travelers. At the moment, this is a unimodal model (train only) but NS aims for a multimodal model in the future including bus, tram and metro. Therefore, NS wants to gain more insights into the different factors affecting transfers between the train and BTM. Furthermore, NS can use the results to identify and take away possible barriers to improve the door to door journey and thereby contribute to their door to door strategy.

1.2 Objective and research questions

The main objective of the research is formulated as follows:

"To determine the transfer disutility of a transfer between BTM and train and quantify the influence of travel time, transfer time, headway, costs and station facilities on such a transfer. Furthermore, differentiate these attributes for personal and trip characteristics."

To achieve this objective, several research questions are defined and are summed up below:

1. What are important attributes influencing the disutility of a transfer between train and BTM according to literature?
2. How do personal- and trip characteristics influence the perceived transfer disutility according to literature?
3. What is the trade-off between in-vehicle time BTM, transfer time, in-vehicle time train, costs, headway and station facilities in combined BTM-train trips?
4. How do personal characteristics and trip characteristics influence the importance of the different travel attributes?
5. What is the transfer disutility of a BTM-train transfer, relative to the transfer disutility of a train-train transfer?
6. To what amount can the transfer disutility be decreased by changing the transfer characteristics?

1.3 Delimitation of research

To narrow the scope further, the main delimitations of the research are mentioned in this section. The research focusses on transfers between trains and bus/tram/metro. Other modalities like walking, cycling and car are excluded from this research. This is done because the aim of the study is to establish the transfer disutility between BTM and train. By excluding the other modalities, the complexity of the study is decreased.

The research focuses on transfers on the bigger stations of the Netherlands, classified by NS as station type 1, station type 2 and station type 3. These are the very big stations in the center of a big city (station type 1, 6 stations), the big stations in the center of a medium-sized city (station type 2, 30 stations) and stations with a transfer function in the suburb of a city (station type 3, 11 stations). These stations are chosen because the modal share of BTM as access/egress mode is far greater (24% - 47%) than the modal share of BTM at the type 4-6 stations (6% - 13%). More information on station typologies is included in section 2.1.2

Different definitions on access mode and egress mode exist. In this study, the access mode is the main mode used by the traveler to get from home to the train station on the outward trip and the main mode used by the traveler from the train station to home on the return trip. The egress mode is the main mode used to get from the train station to the destination on the outward trip and the main mode used to get from the destination to the train station on the return trip.

Respondents for this research are members of the NS panel (discussed later in section 4.1). The use of this panel is chosen because a large amount of respondents is available through this panel. Furthermore, several characteristics of respondents are known in advance, which makes it possible select respondents based on these characteristics.

1.4 Research design

To achieve the research objectives and answer all the research questions, a research design is developed. A schematic representation is included in Figure 3. To start, a literature study will be performed to identify the main components of transfer disutility in a public transport trip. Furthermore personal- and trip characteristics which influence the perceived transfer disutility are identified. The third subject of the literature study concerns choice modelling. Different types of data collection will be discussed and theory on choice modelling will be explained. Based on the information obtained in the literature study, a survey will be developed. The survey consists of an SP experiment and general questions to obtain more information on the respondent. Data collection will take place through an online survey, distributed among members of the NS panel.

Once the data collection is complete, the data analysis can be performed. Firstly, the data will be filtered to exclude unreliable respondents from the data. Based on the filtered data, a model will iteratively be estimated. Furthermore, extra analyses will be performed on the data obtained in the general questions of the survey. The obtained results are validated with findings from previous studies. The last part of the research contains the application of the model. An explanation is provided on how the model should be interpreted and conclusions and recommendations will follow from the model outcomes as well.

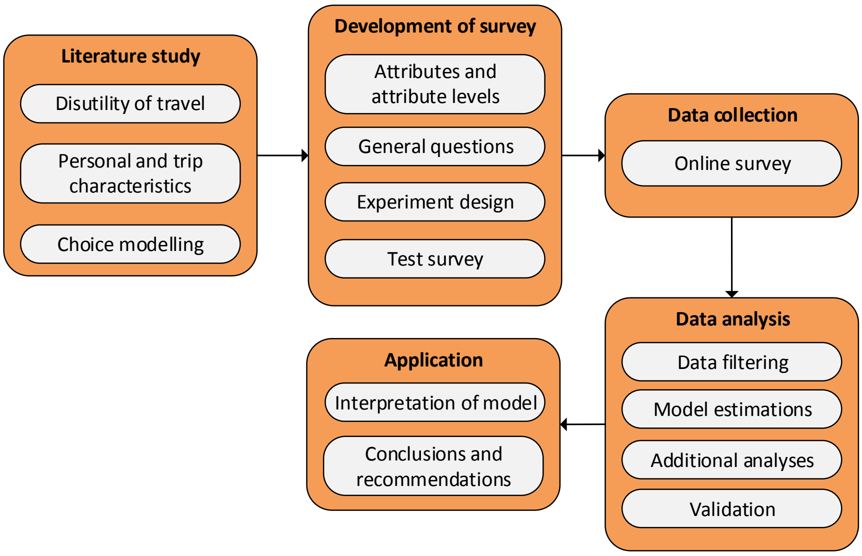


Figure 3: Schematic representation of the research methodology

2. Literature study

This chapter contains the literature study which will be used as input for the survey design. To start, the different elements of a public transport trip are described. The second part of this chapter describes the attributes identified in literature which influence the transfer disutility. These are both general attributes as well as personal- and trip characteristics. The last section provides an analytical framework concerning choice modelling.

2.1 Context description

This section describes the general elements of a public transport trip including a transfer. Furthermore, the differences between station typologies are explained.

2.1.1 Multimodal public transport trip

A train trip is often only a part of the total trip chain of a traveler since the trip chain consists of multiple trip links. In general, such a trip can roughly be divided in the following stages:

- The trip starts at the origin where the trip is prepared;
- An access trip connects the origin with a train station;
- A transfer has to be made from the access mode to the train;
- The train trip connects the origin train station and the destination train station;
- Eventually a transfer between trains might be needed;
- At the destination station a transfer has to be made to the egress mode;
- An egress trip connects the train station with the destination;
- The trip ends at the destination.

The elements mentioned above are visualized in Figure 4. The transfers access mode – train and train – egress mode (indicated in green in Figure 4) are the subject of interest in this research. According to Krygsman, Dijst, and Arentze (2004), the access and egress stage, together with wait and transfer times, are the weakest part of a multimodal public transport chain, thereby having an substantial contribution to the total travel disutility.

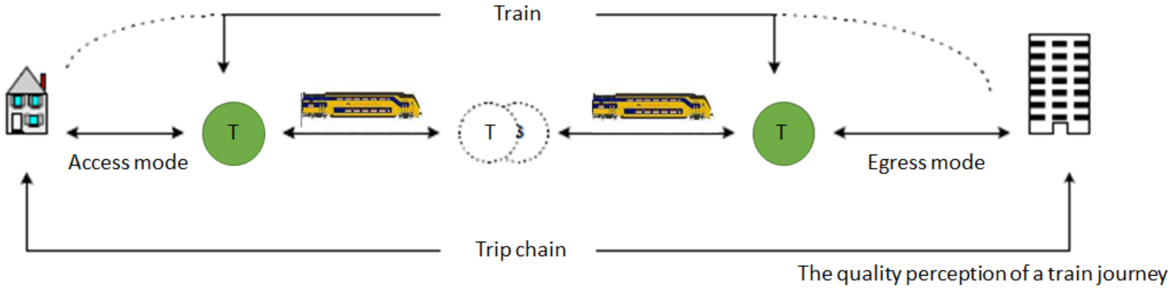


Figure 4: Multimodal transport chain consisting of different elements (adapted from MuConsult, 2014)

2.1.2 Typology of train stations

NS distinguishes six station typologies, based on city size, function and location. Table 3 shows the description of each station type. Furthermore, the percentage of trips where BTM is used as an access or egress mode is included. It shows that the percentage of access and egress trips by BTM is relatively high for station type 1 – 3. Therefore, these station types are the main subject of this study.

Table 3: Overview of station typologies used by NS (based on internal NS documentation, year 2012).

Station type	Description	# Stations in the Netherlands	# Stations operated by NS	Access by BTM (only NS stations)	Egress by BTM (only NS stations)
1	Very large station in the center of a big city.	6	6	47%	37%
2	Large station in medium-sized city	30	30	27%	24%
3	Suburban station with hub function	11	11	42%	39%
4	Station at center of small city/town	147	95	9%	13%
5	Suburban station without hub function	108	85	8%	11%
6	Station in outer area of small city/town	95	51	6%	11%
Total		397	278	22%	26%

2.2 Disutility of travel and transfer

The decision to make a trip with a certain modality to a certain destination is based on the estimated utility of being on the destination and the estimated disutility of traveling (Adler & Ben-Akiva, 1979). The disutility can follow from all the elements of a trip mentioned in section 2.1.1. The traveler will choose if he makes a trip, what will be the destination, what modality is used, at what time the travel takes place and what route will be used (Planbureau voor de leefomgeving, 2009). All these decisions are based on the utility of being on a destination and the disutility of different trip alternatives. The utility will be expressed in generalized costs, which is explained in the next section.

The disutility of a trip experienced by the traveler is built up of three components: travel time, travel costs and effort (van Hagen, 2011; Hoogendoorn-Lanser, 2005; Horowitz & Thompson, 1994; Planbureau voor de leefomgeving, 2009). These three components will be discussed below in separate paragraphs. The disutility of travel in general will be discussed but the focus will lay on the transfer disutility.

2.2.1 The concept of generalized costs

The components time, costs and effort are hard to compare directly. Therefore it is convenient to use a measure combining all the attributes related to the disutility of the journey, which is normally referred to as generalized costs. These generalized costs can be measured both in money or time units. This study will measure the utility in time units, by fixing the utility of a minute in train time to 1. This will further be referred to as generalized travel time (GTT). The utility function is often a linear function of the attributes of the journey weighted by coefficients which attempt to represent their importance as perceived by the traveler (Ortuzar & Willumsen, 2006). A simple example of such a utility function for a trip consisting of an access trip by bus and a main trip by train is shown below.

$$U = \beta_1 t_{bus} + \beta_2 t_{train} + \beta_3 t_{transfer} + \beta_4 C + \beta_5 \delta$$

Where:
t_{bus} = the in-vehicle time in the bus
t_{train} = the in-vehicle time in the train
$t_{transfer}$ = the time between the arrival of the bus and the departure of the train
C = the costs for the total trip
δ = a penalty expressing the effort which is needed for the transfer
$\beta_{1...5}$ are weights attached to each element of disutility.

This way, continuous variables can be expressed in in-train time, for example β_1 could have a value of 1.5, meaning that a minute by bus is valued with the same disutility as 1.5 minute by train. This can be applied to the dummy variables as well, for example β_5 can have a value of 10, meaning that the same disutility is awarded for a transfer as for 10 minutes in-train time.

2.2.2 Travel time

Travel time is one of the three components contributing to the disutility of travel (besides costs and effort). An important principal when considering travel time is the travel time perception of a traveler. This travel time perception of the traveler is not constant (van Hagen, 2011), but consists of several components, with their own characteristics and specific influence on mode choice (vande Walle & Steenberghen, 2006). vande Walle and Steenberghen (2006) distinguish preparation time, walking time, waiting time, transfer time and in vehicle time. The transfer time is an extra penalty which varies between 5-20 minutes. Planbureau voor de leefomgeving (2009) uses the distinction of access and egress time, travel time, waiting time and transfer penalty. The average shares of these components in a trip are shown in Figure 5, expressed in generalized travel time.

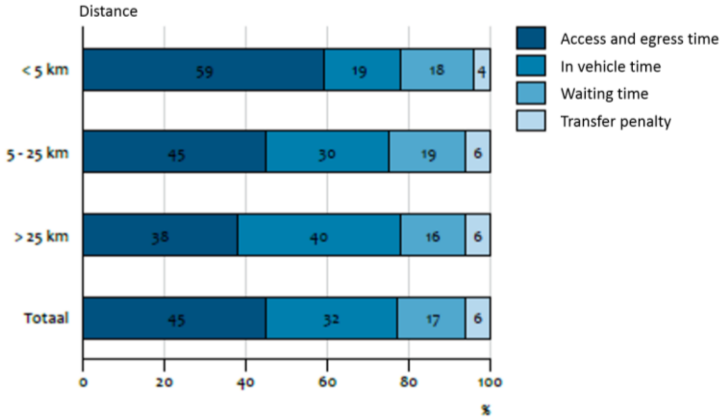


Figure 5: Generalized travel time in a public transport trip (Planbureau voor de leefomgeving, 2009)

van Hagen (2011) distinguishes the following time components: the time on the origin and destination, the time during access and egress trips, the train movement and the transfer between modes. Figure 6 shows that the transfer between modes is the least appreciated part of the trip. Furthermore, the figure shows that in-vehicle time in access and egress modes is appreciated less than the in-vehicle time in the train.

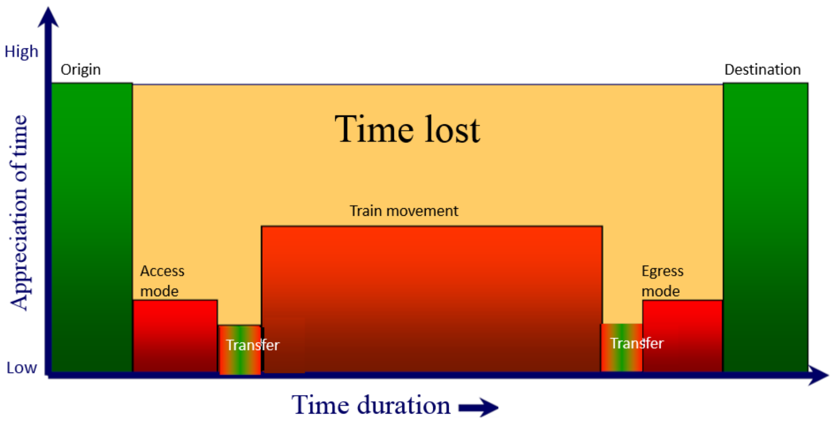


Figure 6: The appreciation of time during different parts of the trip (van Hagen, 2011)

In conclusion, there is consensus in literature that the travel time perception differs for access- and egress time, main travel time and transfer time, with transfer time being the least appreciated part of the trip chain.

When considering the travel time of the transfer, this time can be divided further into two components (Hine & Scott, 2000; Iseki & Taylor, 2009; Ortuzar & Willumsen, 2004; Vleugels, Asperges, Steenbergen, Toint, & Cornelis, 2007):

- Walking time from one modality to the connecting modality;
- Waiting time at the connecting modality.

Some findings on walking time and waiting time during a transfer are found in literature:

- According to Hine and Scott (2000) trips with walking distances exceeding 5-10 minutes become increasingly unattractive;
- The value of waiting time is higher for those who faced a longer pre-transit trip (Gorter, Nijkamp, & Vork, 2000);
- Sensitivity to out-of-vehicle time is 1.5 to 2.3 times the sensitivity to in-vehicle time, according to different estimations (vande Walle & Steenberghen, 2006);
- According to a meta-analysis, waiting time is experienced as 1.7 times the in-vehicle times (27 studies) and walking time is experienced as 1.65 times the in-vehicle time (63 studies). (Abrantes & Wardman, 2011).

2.2.3 Monetary travel costs

The monetary travel costs contribute to the financial disutility of the trip. Public transport in the Netherlands mostly uses one integrated ticketing system (OV-chipcard) which can be used for all modalities. However, there is not one ticket price for the complete trip. Each public transport service provider in the trip chain calculates its own fare. This fare is based on a basic fare and a variable fare dependent on the distance of the trip. If a traveler transfers between train and BTM, the basic fare have to be paid to both public transport service providers, while only one basic fare will be paid in a direct trip. Therefore, the costs of an extra basic fare can be seen as the costs for a transfer. The traveler might not experience transfer costs as such, since these costs are included in the different trip fares and therefore these costs are not easily distinguished from the other costs.

2.2.4 Effort

Next to travel time and monetary travel costs, effort is the third element contributing to the disutility of travel. Effort is not limited to physical effort but includes cognitive (mental) and affective (emotional) effort as well (Wardman et al., 2001a). A mainly qualitative summary of factors influencing the transfer penalty according to literature is provided in Table 4 on the next page. The literature summarized in Table 4 mentions several factors which together determine the total transfer disutility. A sequential approach is suggested by van Hagen (2011). Analogous to Maslow's pyramid, a pyramid of costumer needs during trips is developed (Figure 7). It is argued that safety and reliability are the most important elements. If a station is perceived as unsafe or unreliable by a traveler, this traveler will avoid the station. The next main traveler need is speed. When these factors are fulfilled satisfactory, ease, comfort and experience get important. Preston et al. (2008) use a similar pyramid to describe the experience of stations. A distinction is made between travelers who move through a station (speed and ease are important) and travelers who stay at a station (comfort and experience are important). However, a safe, reliable, easy and speedy journey remains important for all travelers (van Hagen, 2011).

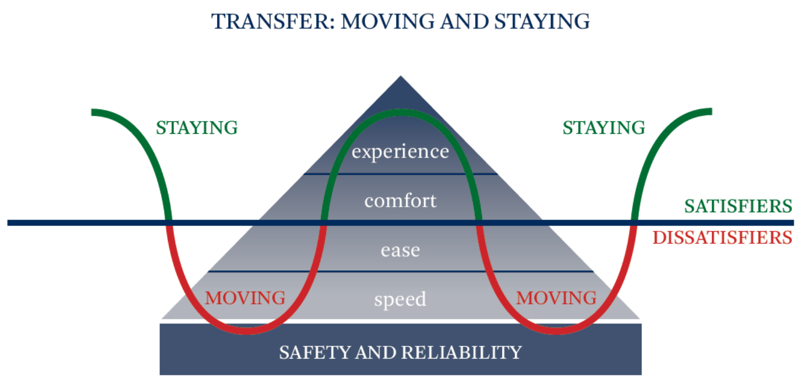


Figure 7: Customer needs pyramid (van Hagen, 2011)

Table 4: Attributes identified in literature contributing to the transfer disutility

Attribute	Effect according to literature
Travel Information	• Accurate information should be provided at the start of the trip, during an interchange and when in the process of using the service (Hine & Scott, 2000) • Before and during the travel should be available: fares information, route maps, time tables and arrival times (Palmer, James, & Jones, 2011; Wardman et al., 2001a). • Real-time on-site information is the best type of information for multi-modal journey planning (London Transport, 1997, cited in Wardman & Hine, 2000) • Travelers get discouraged by increased complexity and missing information and guidance (Rehrl, Leitinger, Bruntsch, & Mentz, 2005) • Information at transfer stops can significantly influence the transfer experience because poor information can lead to wandering, stress and uncertainty about the transfer (Iseki & Taylor, 2009) • Information about bus stops is especially important for the egress trip since travelers are often unfamiliar with the situation (MuConsult, 2006)
Safety	• Social safety is a prerequisite for the functioning of a station as a public space. If potential travelers perceive a station as unsafe, they will avoid it (van Hagen, 2011; Iseki & Taylor, 2009) • Personal security is a major issue, especially in interchanges on dark mornings and late at night (Hine & Scott, 2000) • Safety and security are very important factors determining the station experience since they can increase the perceived waiting time infinitely (Iseki & Taylor, 2009) • Safety is a central factor for successful transfers (Hine et al., 2003; Palmer et al., 2011)
Uncertainty	• Users need to feel that they will reach their destination on time (Hine & Scott, 2000) • A guaranteed transfer can reduce the penalty for a bus transfer from 4.5 minutes to 3.6 minutes. The transfer penalty for train users van be reduced from 8 minutes to 4.4 minutes with a guaranteed transfer. (Wardman et al., 2001a)
Frequency/ headway	• After safety, frequency is the most important attribute influencing the transfer penalty (Iseki & Taylor, 2010) • Short headways in the destination line leads to convenient transfer. Long headways in the destination line require information about the connecting run (Vuchic, 2005)
Reliability	• The reliability of travel time is one of the main indicators for a social cost benefit analyses (Kennisinstituut voor Mobiliteitsbeleid, 2013; Significance, VU University, & John Bates Services, 2012), which shows that this is seen as very important. • The bus is often unreliable, resulting in an unreliable trip chain (MuConsult, 2006) • Passengers should experience receiving what they expect. This is the basis of the customer satisfaction (van Hagen, 2011) • Reassurance that the bus or train is waiting at the station is a key feature of a good interchange (Wardman, 1988) • Within a multimodal transport trip, a 50% probability of a 2 minute delay is valued as 64 cents (Rietveld, Bruinsma, & van Vuuren, 2001)
Station facilities	• Shelter from weather is important (Palmer et al., 2011; Wardman et al., 2001a) • Transfer penalties are lower where escalators are present (Haarsman, 2012) • Travelers will experience their time more positive in a pleasant environment. This can be achieved by shelter and seating, background music, calming colors, beautiful view or television screens. (van Hagen, 2011) • Availability of shops and cafes enhance a pleasant stay (van Hagen, 2011)
Transfer type	• For a transfer between trains, a cross platform transfer is perceived better than a cross station platform (Haarsman, 2012). This effect might also be applicable on train-BTM transfers since different type of transfers exist here as well.
Availability of staff	• Visible staff present at stations is indicated as important or very important by 74% of the travelers (Oscar Faber, 1996, as cited in Wardman & Hine, 2000)
Tickets	• Integrated ticketing systems improve journey for passengers (Hine & Scott, 2000; Palmer et al., 2011)
Seat availability	• Concerns about having a seat in the connecting train is the most disliked aspect of transfers for 15% of the travelers (Hine et al., 2003)

2.2.5 The effect of personal and trip characteristics on the transfer disutility

The valuation of the attributes mentioned in the previous three paragraphs will vary among travelers, dependent on several personal and trip characteristics (Hine et al., 2003; Wardman & Hine, 2000). A main distinction in traveler type used by NS is the 'must' traveler and the 'lust' traveler. van Hagen (2011) describes a 'must' traveler as someone who regularly and systematically travels by train. For these type of travelers, goal-orientedness and time play an important role (Hine et al., 2003). 'Lust' travelers only travel incidental and attach greater value to the convenience and comfort of the journey. Whether someone is a must or a lust traveler can be derived from the trip motive and the travel frequency. The main trip motive for the must traveler is work, business or school, while the lust traveler often travels with a social-recreational trip motive.

The personal characteristics found in literature which influence the disutility of a transfer are summarized in Table 5. Furthermore, the trip characteristics which influence the disutility of a transfer are summarized in Table 6.

Table 5: Personal characteristics influencing the transfer disutility

Personal characteristic	Effect according to literature
Trip motive	The transfer disutility experienced by commuters is lower than for the leisure travelers (Wardman et al., 2001a) Travelers with a business trip motive have by far the highest value of time (€19/hour) and value of reliability (€21,75/hour) in comparison with the value of time (€6-€7,75/hour) and the value of reliability (€3,25-€3,75/hour) for commuters and leisure travelers (Significance et al., 2012).
Luggage	Luggage handling is most disliked aspect of interchange (Hine et al., 2003; Palmer et al., 2011)
Familiarity with station	Familiarity with the station is the most important positive aspect influencing transfer disutility (Hine et al., 2003; Wardman & Hine, 2000)
Traveling with children	Traveling with young children influencing the transfer disutility negatively (Hine et al., 2003)
Gender	The total transfer disutility is larger for females and females have a 26% higher value of waiting time and a 23% higher value of walking time (Wardman et al., 2001a).
Age	Transfer disutility is larger for people older than 50 (Wardman et al., 2001a)

Table 6: Trip characteristics influencing valuation of transfer attribute values

Trip characteristic	**Effect according to literature**
Trip length	The transfer disutility varies with the trip length, however the effect is not clear and differs per mode (Wardman & Hine, 2000)
Time of day	The time of day might influence the perceived safety which is identified in Table 4 as an important attribute
Trip stage	No literature is found on the possible difference in transfer disutility for access trips and egress trips.
Mode	- The transfer penalty for a bus-bus transfer is smaller than train-train transfer (Wardman et al., 2001a) - The transfer penalty is greater for connections between rail and other modes than rail to rail (Palmer et al., 2011)

2.2.6 Conceptual model

The previous paragraphs showed that there is a large variety of attributes contributing to transfer disutility. These attributes can be grouped in the components time, costs and effort. Furthermore, the valuation of these elements differs for several personal- and trip characteristics. A conceptual model including all attributes and characteristics identified in literature concerning the transfer disutility is shown in Figure 8.

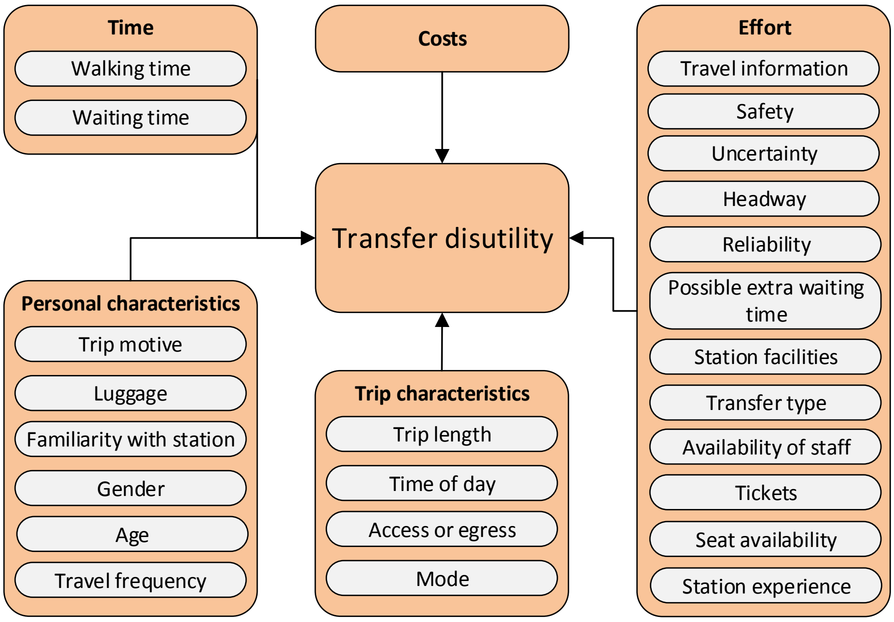


Figure 8: Qualitative overview of attributes and characteristics influencing transfer disutility

2.3 Analytical framework

This section describes the theory on choice modelling. Firstly, the standard multinomial logit model is explained. Secondly, a theoretical explanation is given on how to compare the different models. Thirdly, a variation on the multinomial logit model, the mixed logit error component model is discussed. Fourthly, the advantages and disadvantages of revealed preference data are compared with stated preference data.

2.3.1 Multinomial logit model

According to the random utility theory, an individual (q), choses between a set of mutually exclusive, exhaustive set of alternatives (A_i) an alternative (i) which maximizes the utility of that individual (Train, 2009). The perceived utility U of an alternative i by an individual q is built up of two components: a systematic component V_{iq} and a random component ϵ_{iq}. (McFadden, 1974). The systematic component is built up of one or more attributes, which can be observed by the modeler. The random component reflects unobserved attributes and imperfect measurements by individuals (Louviere, Hensher, & Swait, 2000; Train, 2009). It is assumed that ε_{iq} is independently, identically distributed extreme value over alternatives and people (Train, 2009, p. 34). Considering the simplest utility function with linear parameters, V_{iq} can be expressed as

$$V_{iq} = \sum_k \beta_{ik} X_{ikq} \qquad \textit{(Equation 1)}$$

Where β are the parameters to be estimated and X are the attributes of alternatives or socioeconomic characteristics of the individuals as observed by the modeler (Navarette & Ortuzar, 2013). With the inclusion of the error component U_{iq} can be expressed as

$$U_{iq} = V_{iq} + \varepsilon_{iq} = \sum_k \beta_{ik} X_{ikq} + \varepsilon_{iq} \qquad \textit{(Equation 2)}$$

Since it is assumed that travelers act according to the random utility theory and maximize their utility, an individual q will choose alternative *i* if (Louviere et al., 2000):

$$U_{iq} > U_{jq} = \left(V_{iq} + \varepsilon_{iq}\right) > \left(V_{jq} + \varepsilon_{jq}\right) \quad \text{all } j \neq i \in A \qquad \textit{(Equation 3)}$$

This disaggregated approach makes the individual decision maker the unit of observation and aims to explain the sensitivity of individuals' choices to relevant travel attributes. This is done by comparing different individuals' choices in different situations (Wardman, Hine, & Stradling, 2001b). Several models are available to estimate travelers' choices, but the multinomial logit (MNL) model is by far the most commonly used model (Train, 2009; Wardman et al., 2001b). An advantage of the MNL model is that it can represent taste variation that relates to observed characteristics of the decision maker (Train, 2009). This is a useful property since the taste variation due to personal characteristics is one of the concerns of this research.

Assumed in this model is that ε_i, i=1,2,…,N are independent and identically Gumbel distributed (IID). Moreover, the ratio of choice probability for an individual is unaffected by the systematic utilities of any other alternatives (IIA) (Louviere et al., 2000). With these assumptions, according to the MNL model, the chance that an individual chooses a certain alternative is (Louviere et al., 2000):

$$P_{iq} = \frac{e^{V_{iq}}}{\sum_{j=1}^{N} e^{V_{jq}}} \qquad \textit{(Equation 4)}$$

The MNL model can be estimated by using the maximum likelihood method (Louviere et al., 2000; Train, 2009). The function expressing the probability of the particular outcome x of an experiment, X, is represented by $P_x(x \mid \beta)$. Where β is a vector containing the parameters of the model (β_1, β_2, …, β_r). If the vector β is known, the joint probability function of a random sample of experiments X_1, X_2,…,X_T can be written as (Louviere et al., 2000):

$$P_{X_1,X_2,\ldots,X_T}(x_1, x_2, \ldots, x_T|\beta\,) = P_{x1}(x_1|\beta) \cdot P_{x2}(x_2|\beta) \cdot, \ldots, P_{x_T}(x_T|\beta) = \prod_{t=1}^{T} P_{X_t}\,(x_t|\beta) \qquad \textit{(Equation 5)}$$

However, β is unknown and it is the aim to estimate this vector of parameters. If a specific sample set of experiments, X_1, X_2,…,X_T is observed and has outcomes x_1, x_2,…,x_t, the right-hand part of equation 5 expresses the probability of having observed this particular sample, as a function of β, thus (Louviere et al., 2000):

$$L(\beta|x_1, x_2, \ldots, x_T) = \prod_{t=1}^{T} P_{X_t}\,(x_t|\beta) \qquad \textit{(Equation 6)}$$

Equation 6 is called the likelihood function. This likelihood function can be evaluated for different values of β. Values for β which yield a larger value for the likelihood are better estimates for the model. Therefore, the values for β which causes the likelihood function to be a maximum are the best estimates. This maximum likelihood estimation is performed in this study by the software program BIOGEME (Bierlaire, 2003). It is often easier to maximize the logarithm of the likelihood function instead of the likelihood function itself. If this is the case, the equation becomes (Louviere et al., 2000):

$$\ln\big(L(\beta)\big) = \prod_{t=1}^{T} \ln(P_{X_t}\,(x_t|\beta)) \qquad \textit{(Equation 7)}$$

2.3.2 Goodness of fit measure

In first instance, a simple MNL model is estimated only including a few attributes. Based on this model, several other MNL models are estimated which include several trip- and personal characteristics. A statistic called the likelihood ratio index is often used to measure how well the models fit the data (Train, 2009). In this statistic, the log likelihood function (Equation 7) with the estimated parameters is compared with the log likelihood function where all the parameters are zero. The likelihood ratio index is defined as (Louviere et al., 2000; Train, 2009):

$$\rho^2 = 1 - \frac{LL(\hat{\beta})}{LL(0)} \qquad \textit{(Equation 8)}$$

The likelihood ratio index is not at all similar in its interpretation compared to the R^2 which is often used in regression (Train, 2009 p.68). The meaning of 0 (no fit) and 1 (perfect fit) are clear, but values between these limits do not have a intuitive interpretation (Ortuzar & Willumsen, 2006, p. 265). Values of ρ^2 between 0.2 and 0.4 are considered to be indicative of extremely good model fits (Louviere et al., 2000, p. 54). The ρ^2 statistic can be improved by adjusting for degrees of freedom, which is useful when comparing different models (Louviere et al., 2000, p. 55). The adjusted ρ^2 statistic is defined as

$$\text{Adjusted } \rho^2 = 1 - \frac{LL(\hat{\beta})-K}{LL(0)} \qquad \textit{(Equation 9)}$$

Where K is the number of estimated parameters.

2.3.3 Comparison of model specifications

In general, a model will perform better when more parameters are added. To compare the performance of different subsets of variables, the likelihood ratio test can be performed (Louviere et al., 2000, p. 53; Ortuzar & Willumsen, 2006, p. 263): For this test, the log-likelihood at convergence of the original model (LL_{model1}) is compared with the log-likelihood at convergence for the model with the additional parameters ((LL_{model2}). The LR statistic,

$$-2\{LL_{model2} - LL_{model1}) \qquad \textit{(Equation 10)}$$

is asymptotically distributed χ^2 with r degrees of freedom, where r is the number of extra parameters added. Only when the LR statistic is higher than the χ^2 value for r degrees of freedom, the model with extra parameters is considered significantly better than the original model.

2.3.4 Mixed logit model

The MNL model is widely used to model travel behavior, but has several limitations. A main disadvantage of the MNL model is that it assumes that all observations are independent. However, if one person is faced with several choice situations (multiple observations), the chance is very high that these observations within one person are not independent. Therefore an error component mixed logit model can be more suitable, since it allows to take the panel effect of multiple observations per respondent into account. Mixed logit models are the integrals of standard logit probabilities over a density of parameters. According to Train (2009) a mixed logit model is any model whose choice probabilities can be expressed in the form:

$$P_{iq} = \int L_{iq}(\beta) f(\beta) d\beta \qquad \textit{(Equation 11)}$$

Where $L_{iq}(\beta)$ is the logit probability evaluated at parameters β and f(β) is a density function:

$$L_{iq}(\beta) = \frac{e^{V_{iq}(\beta)}}{\sum_{j=1}^{J} e^{V_{jq}(\beta)}} \qquad \textit{(Equation 12)}$$

If utility is linear in β, then $V_{iq}(\beta) = \beta' x_{ni}$. In this case the mixed logit probability takes it usual form:

$$P_{iq} = \int \left(\frac{e^{\beta' x_{ni}}}{\sum_j \beta' x_{nj}}\right) f(\beta) d\beta \qquad \textit{(Equation 13)}$$

"The specification is easily generalized to allow for repeated choices by each sampled decision maker. The simplest specification treats the coefficients that enter utility as varying over people but being constant over choice situations for each person" (Train, 2009, p. 145). With a sequence of choices, the probability that a person makes this sequence of choices is the product of logit formulas (Train, 2009, p. 146):

$$L_{iq}(\beta) = \prod_{t=1}^{T} \left[\frac{e^{\beta_n' x_{ni_t t}}}{\sum_j e^{\beta_n' x_{njt}}}\right] \qquad \textit{(Equation 14)}$$

The best MNL model will also be adapted to a mixed logit model. The reason to start with MNL models is the long computation time for ML models.

2.3.5 Revealed preference data versus stated preference data

The data upon which the models will be calibrated can be based on individuals' real choices or individuals' choices amongst hypothetical travel alternatives (Wardman et al., 2001b). These two main types of data collection methods in the analysis of travel behavior are called revealed preference (RP) and stated preference (SP). In a revealed preference study, the real choice of a traveler is obtained by direct observation or in surveys asking for actual travel behavior. In a stated preference study, the respondent is provided with two or more hypothetical alternatives and is asked to choose the preferred alternative.

A meta-analysis of Abrantes and Wardman (2011) including 226 studies on values of travel time showed that stated preference is the most popular method for this research subject and is used in 87% of the studies (in recent years even 97% of the studies used stated preference). Both types of data collection have their own advantages and disadvantages.

The main advantage of RP is that the results are based on actual decisions (Mark & Swait, 2004; Train, 2009). There is a high reliability and validity due to the measurement system (Louviere et al., 2000; Verhoef & Franses, 2002). On the other hand, there are several disadvantages as well. Firstly, it is difficult to obtain sufficient variation in the data to examine all variables of interest (Kroes & Sheldon, 1988; Louviere et al., 2000; Verhoef & Franses, 2002). Secondly, strong correlations between explanatory variables exist, making it difficult to estimate model parameters (Kroes & Sheldon, 1988) and thirdly unobserved variables can influence the outcome.

Compared to RP, SP is more flexible and cheaper to apply (Kroes & Sheldon, 1988; Louviere et al., 2000; Verhoef & Franses, 2002). Furthermore, it is easy to control the attribute values in a SP experiment (Kroes & Sheldon, 1988). Another advantage is that it can be used to evaluate demand under conditions which do not exist yet (Kroes & Sheldon, 1988; Louviere et al., 2000; Train, 2009; Verhoef & Franses, 2002). The last main advantage of SP is that new variables can be introduced that may explain choices which are not captured by RP data, like satisfaction (Verhoef & Franses, 2002). The main disadvantage of SP is that there may be a discrepancy in what respondents say they do and what they actually do (Kroes & Sheldon, 1988; Verhoef & Franses, 2002). Respondents might give other answers than their real behavior because they try to justify their actual behavior, control policies (Sanko, 2001) or they may not know what they would do if a hypothetical situation was real (Train, 2009). Other problems are a systematic bias in the SP responses and task complexity (Louviere et al., 2000). If the respondent does not understand the question, or the amount of attributes is too high, a respondent might not be able to make a good comparison.

Taking into account the considerations stated above, this study will be based on an adaptive stated preference experiment. The aim of this study is to quantify different attributes and their relative importance. A SP experiment is most suitable because of the ability to control the included attributes. The SP experiment will be adaptive, which means that some attribute values are based on the current travel behavior of the traveler obtained by RP questions. This will lead to more realistic choices for the respondent and therefore more reliable answers. More information on the adaptive character of the design is provided in section 3.3.2.

Within the category of SP studies, there are different ways to measure preferences. This study will use discrete choice of one option from a set of competing ones. This type of SP study results in less information on relative importance than a complete ranking of option or expressing degrees of preference, but since task complexity is such an important issue (Wardman, 1988), the task will be kept as simple as possible.

2.4 Conclusions

A traveler bases a travel decision on the utility of being on the destination and the disutility of traveling. The main components contributing to the disutility of traveling are time, costs and effort. In accordance with the random utility theory, it is assumed that a traveler choses the option which maximizes the total utility. The perception of time is not constant during the trip but differs for in-vehicle time, walking time and waiting time. The effort of a transfer consists of elements as travel information, safety, uncertainty, reliability, station facilities and the availability of staff. The valuation of each of these attributes differs between persons and between trips.

Discrete choice models will be applied to determine the valuation of transfers and the relative importance of specific attributes within these transfers. Furthermore, distinctions for different personal- and trip characteristics will be modeled within these models. The multinomial logit model will be applied with several specifications to find the best suited model. Furthermore, a mixed logit model will be estimated, to account for dependent observations within one respondent. Stated preference data is used since this type of data is best suited for this study.

3. Survey design

This chapter reports on the development of the survey which is used for the data collection. The first section gives an overview of the different parts of the survey. The second section describes the general setup of the SP experiment. The third section defines the attributes and attribute levels within the SP experiment. The experiment design is discussed the fourth section.

3.1 Survey overview

The survey consists of several parts, the subjects of all the questions are summarized in Table 7 on the next page. The complete survey with the routing, the full formulation of the questions and the answer options is added in appendix A.

The survey starts with general questions regarding the travel behavior of the respondent. With these general characteristics, sub models can be estimated for specific trip motives or travel frequencies. These questions are placed at the start of the survey since most of the respondents of the NS panel are familiar with these questions. Therefore, such questions are relatively simple to answer which decreases the burden to start, resulting in a higher response rate. The next set of questions asks the respondent about the latest train trip where BTM is used as access or egress mode, which is considered as an RP observation. The specific mode (bus, tram or metro) and the type of transfer (access or egress) are used in the further questions which are based on this trip. Furthermore, travel time, costs and trip motive are asked, since this is an input for the SP experiment. Because the SP experiment can be quite a burden for respondents, the experiment is placed as soon as possible, thus after the needed attribute values from the recent trip are obtained. Elaborate information on the SP experiment is provided in the next sections.

After the SP experiment, the respondents have a possibility to make remarks about the SP experiment. This is done because most of the respondents are unfamiliar SP experiments. By providing a possibility to make remarks about the experiment, it can be checked whether or not most of the respondents understood the questions. Then, the respondent is asked to assess the used transfer station for six different aspects. This is done by questions similar to the "Stationsbelevingsmonitor", a yearly survey conducted by NS. Furthermore, the preferred transfer time for the specific transfer station is asked. This way, the preferred transfer time can be derived both directly and from the model estimations.

In the end, questions are included about socioeconomic characteristics, like income or age. For sensitive questions, an option "I do not want to tell" is included. Therefore, respondents are not forced to give an answer on these questions, which might lead to a higher response rate.

Table 7: Overview of survey questions

Question	Subject	Obtained information
1	Travel frequency train	Travel characteristics
2	General trip motive	Travel characteristics
3	Frequency BTM access trip	Travel characteristics
4	Frequency BTM egress trip	Travel characteristics
5	Origin train station	Input for further RP questions
5	Destination train station	Input for further RP questions
6	Access mode	Input for SP experiment
7	Egress mode	Input for SP experiment
8	Trip motive specific trip	Input for SP experiment
9	In-train travel time	Input for SP experiment
10	Type of train ticket	Costs sensitivity
11	Who pays for trip	Costs sensitivity
12	Costs train trip	Input for SP experiment
13	Access/egress trip time	Input for SP experiment
14	Costs access/egress trip	Input for SP experiment
15	Available access/egress modes	Travel characteristics
	Access SP experiment	Model estimation data
	Egress SP experiment	Model estimation data
16	Remarks SP experiment	Survey quality
17	Transfer time specific trip	Information RP trip
18	Preferred transfer time specific trip	Preference
19	Headway of connection	Information RP trip
20	Assessment of elements transfer station	Assessment
21	Gender	Socioeconomic characteristics
22	Age	Socioeconomic characteristics
23	Working situation	Socioeconomic characteristics
24	Income	Socioeconomic characteristics
25	Education	Socioeconomic characteristics
26	Postal code	Socioeconomic characteristics
27	Remarks about BTM-train transfer	Elements not captured in the survey
28	General remarks	Survey quality

3.2 Description of the SP experiment

This section discusses the type of choice situations which are presented to respondents, the division of different choice situations among the respondents and the context description.

3.2.1 Type of choice situations

Respondents are presented different travel options to travel from one point to another point in the SP experiment. A normal trip by public transport often consists of two or more transfers (access trip to main trip and main trip to egress trip) as is described in section 2.1.1. However, in the choice situations in this study, only one transfer is included to keep the task complexity low. This means that either the access trip or the egress trip is not included in the described choice situations.

To determine the contribution of individual attributes towards the transfer disutility of a BTM-train transfer, choice situations within one alternative are presented. Both choice options represent a trip with a BTM access/egress trip and a transfer to or from a train. In this choice situation, the travel alternatives are equal, only the attribute levels differ. To determine the relative transfer disutility of a transfer between BTM and train, a trip including such a transfer is compared with a trip including a transfer between train and train. This means that choice situations between these two alternatives are presented to respondents as well. These distinctions (within/between alternatives and access/egress) led to a total of four types of choice situations to be included in the experiment. An overview of the four types of choice situations is given in Figure 9.

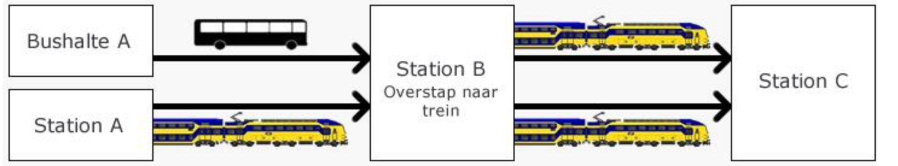
Type of choice situation	Visualization of choice situations
1. BTM-train versus BTM-train in access situation (choice within alternative)	
2. BTM-train versus train-train in access situation (choice between alternatives)	
3. Train-BTM versus train-BTM in egress situation (choice within alternative)	
4. Train-BTM versus train-train in egress situation (choice between alternatives)	

Figure 9: Types of choice situations in choice experiment

Besides the two alternatives in each choice situation, two no choice options (or opt-out alternatives) are included as well. By including a no choice option, respondents are not forced to make a choice between one of the two alternatives when they would not choose any of the presented alternatives in reality. Since the trips are close to normal trips reported by respondents, it was expected that not a lot of respondents will chose for this no choice option. The use of a no choice option has been recommended in literature (Kontoleon & Yabe, 2003). According to Louviere et al. (2000), this ads realism to the experiment. The no choice options are formulated as "I would travel in another way to/from the station" and "I would not make this trip by public transport".

3.2.2 Division of choice situations between respondents

To reduce the amount of respondents needed for this study, respondents are presented more than one choice situation. The amount of choice situations which can be presented to respondents is limited. Most studies evaluate between 1 and 16 choice situations with an average of eight choice situations (Carson et al. (1996) as cited in Louviere et al., 2000). A practical limit of 18 choice situations is suggested by Mangham, Hanson, and McPake (2009) before boredom sets in.

These limits are dependent on the amount of choice options, the number of attribute and the understandability of the attributes. Four out of six attributes in this experiment relate directly to time or costs and are relatively easy to evaluate for respondents. Furthermore, only two alternatives have to be compared in each choice situation, which is an advantage since this is easier for respondents than having to compare more alternatives at once. For these reasons, a total of 12 choice situations for each respondent is considered to be feasible.

The choice situations mentioned in Figure 9 can be divided within respondents, between respondents or a combination of these two options. An advantage of dividing the types of choice situations between respondents is that the context of the choice situation only has to be explained once. After this explanation, the respondent can evaluate the 12 choice situations. This makes the survey less complicated and less time-consuming to complete, which can lead to a higher response rate and more reliable results. Dividing the different types of choice situations within the respondents allows to observe preferences for alternatives within respondents. It means however that four types of choice situations must be explained to respondents. After each explanation, only three choice situations can be answered. This increased task complexity might lead to a lower response rate and less reliable results.

Based on the considerations described above, it is chosen to present half of the respondents 6 choice situations of type 1 and six choice situations of type 2 (the access transfer variants). The other half of the respondents is presented six choice situations of type 3 and six choice situations of type 4 (the egress transfer variants). Whether a respondent is assigned the access or egress variant is dependent on the type of RP trip reported in the survey. With this division, the task complexity stays relatively simple while preferences within respondents for BTM-train or train-train alternatives can be observed. Differences in the valuation between access transfers and egress transfers cannot be observed within a respondent, but can be obtained between respondents.

3.2.3 Context description

It is important to clearly describe the context of the choice situations to respondents. This ensures that all respondents perceive the choice situations in the same way. Since it is expected that the transfer disutility will differ per trip motive, a respondent is given a trip motive for the choice situations. This trip motive is equal to the trip motive reported in the RP trip.

Stations are called “Station A”, “Station B” etcetera in the SP experiment, instead of using specific station names. By mentioning specific station names, unrealistic situations can occur, with possibly less reliable answers as a result. By excluding the station names, it is clear for the respondent that the choice situation is hypothetical.

3.3 Definition of attributes and attribute levels

The literature study in chapter 2 identified the attributes and characteristics influencing the transfer disutility. Including all these attributes into a choice experiment leads to a very high task complexity and therefore unreliable results. Pearmain, Swanson, Kroes and Bradley (1991) as cited in Sanko (2001) suggest a maximum of 6 or 7 attributes in a choice experiment.

3.3.1 Included attributes

Walking time and waiting time are considered very important attributes in a transfer. These attributes are together included as transfer time since literature indicated that the valuation of these two time elements is approximately equal. Furthermore, access/egress time and in-train time are included to make it possible to express all other attributes in time. The monetary costs, as one of the three budgets a traveler has available, is also included, mainly for validation purposes.

Different elements of effort are also important according to literature. Uncertainty, headway, coordination and reliability are attributes which are often mentioned. These attributes are however related to each other: if the headway is shorter, the uncertainty is generally lower and the coordination better. Since the reliability can be measured as a standard deviation around the mean travel time (Kennisinstituut voor Mobiliteitsbeleid, 2013) this is also dependent on the headway. When the headway is decreased, the standard deviation around the mean travel time decreases as well. For these reasons, only headway is included. The choice for this attribute is made because this is the easiest attribute to understand for a respondent. All kind of station facilities are mentioned as important elements during a transfer. This study determines the effect of the station size, thereby representing several elements of station facilities.

Figure 10 shows the conceptual model of section 0 with the attributes influencing the transfer disutility according to literature. The elements which are included in the SP experiment are indicated in green. Furthermore, characteristics from the respondent and context variables which are obtained from the survey are indicated.

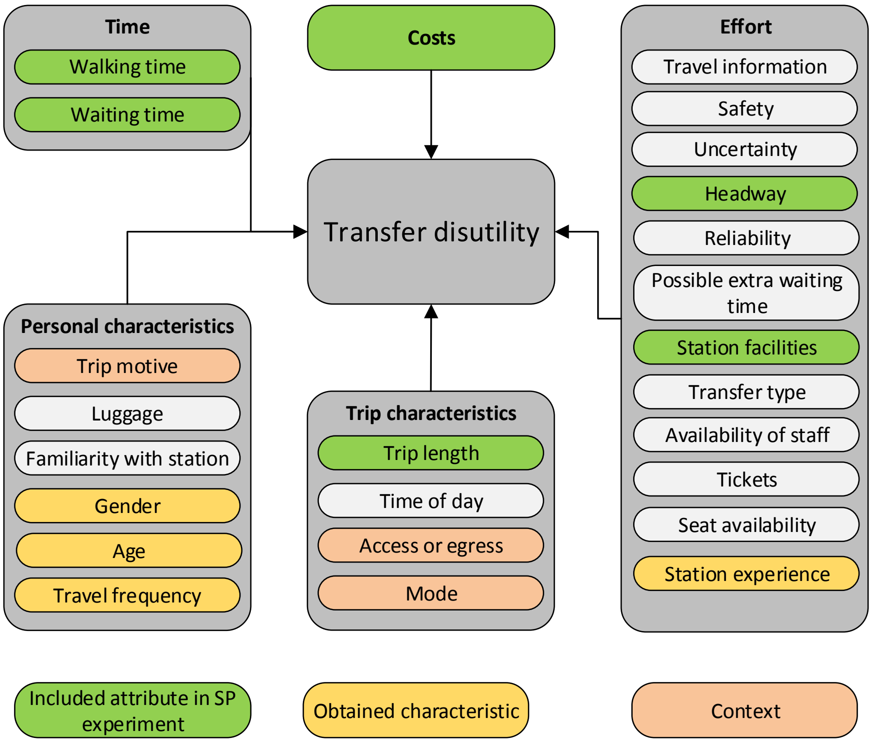


Figure 10: Included attributes and characteristics in SP experiment

3.3.2 Attribute levels

The attribute levels of the attributes selected in the previous section will be established in this section. The values must be realistic, because otherwise the responses can be expected to be less reliable (Fowkes & Wardman, 1988). To ensure that the choice situations presented to the respondents are perceived realistic, the attribute levels for access/egress time, in-train time main trip and costs will relate to the RP trip of the respondent. For the other attributes, levels will be chosen which often occur in reality as well.

Access/egress time (AET)

The in-vehicle time for the access/egress trip is presented to respondents as the scheduled trip time. The attribute levels are adaptive to the trip time by BTM in a recent trip. This is the base level, two lower levels (RP -20%, RP -10%) and two higher levels (RP +10%, RP +20%) are included as well.

Transfer time (TT)

The transfer time is presented as the time difference between the scheduled arrival time of one mode and the scheduled departure time of the next mode. The expected pattern of disutility attached to transfer time is not evident. While in general, large transfer times will be perceived more negatively than small transfer times, very small transfer times can be perceived negative as well. This is caused by the stress experienced by travelers because they have to hurry and the chance that they will miss their connection (Haarsman, 2012).

This attribute is not adaptive since the transfer time for a certain trip can vary. Therefore it might be hard for respondents to estimate their usual transfer time. The smallest attribute level for transfer time in this experiment is 3 minutes, since this is the smallest possible transfer time for a BTM-train transfer in the Dutch routeplanner 9292ov. The largest value of transfer time is 15 minutes, since this value is also dependent on the levels of the headway. For example a transfer time of 25 minutes in combination with a headway of a train every 15 minutes would not make sense. A total of five different levels of transfer times is included.

In-train time main trip (ITT)

Similar to access/egress time, travelers are asked about the estimated trip length of the train trip. This is the base level for the attribute level in-train time main trip. Again, two lower attribute levels (RP -20%, RP -10%) and two higher attribute levels (RP +10%, RP +20%) are included.

Costs (CO)

The attribute level costs represents the total costs of the main train trip and the access- or egress trip. Travelers are asked in the survey to estimate the costs for their indicated BTM trip and train trip. This combined estimation is the base level of the costs attributes. Two lower attribute levels (RP -20%, RP -10%) and two higher attribute levels (RP +20%, RP +10%) are included.

Headway connecting mode (HW)

The attribute headway represents the time interval of the departure of the connecting mode (BTM or train, dependent on the type of choice situation). The included time intervals will be every 15, 20 and 30 minutes. In some occasions headways can be smaller in reality, but these small headways are excluded because these attribute levels would conflict with the high attribute levels for transfer time.

Station facilities (SF)

A qualitative attribute describing the size and facilities of the stations is included. The difference in facilities is described by the type and amount of shops present at the stations. A medium, large and a very large station are distinguished.

An overview of all the attributes and corresponding attribute levels is shown in Table 8.

Table 8: Overview of attributes and attribute levels in choice experiment

Attribute	Attribute levels	Explanation to respondent
Access/egress time (AET)	RP - 20% RP - 10% RP +- 0% RP + 10% RP + 20%	The planned trip time of the access/egress trip according to the schedule.
Transfer time (TT)	3 minutes 5 minutes 8 minutes 11 minutes 15 minutes	The time between the planned arrival time of the first mode and the planned departure time of the connecting mode. You can assume that the walking time for each transfer is three minutes according to route planners like 9292ov.
In-train time main trip (ITT)	RP - 20% RP - 10% RP +- 0% RP + 10% RP + 20%	The planned trip time of the train according to the schedule.
Costs (CO)	RP - 20% RP - 10% RP +- 0% RP + 10% RP + 20%	These are the total costs (including the access/egress trip and the main train trip) for the described trip
Headway connecting mode (HW)	Every 15 minutes Every 20 minutes Every 30 minutes	The time interval of your connecting train/BTM mode.
Station facilities (SF)	Medium	-The transfer station is an average station with one or two shops available to get something to eat or drink (for example a Kiosk). Examples of this station type are Hoofddorp, Ede-Wageningen and Zaandam
	Large	-The transfer station is a large station with three to nine shops available to get something to eat or drink (for example Albert Heijn to go, Burger King and Smuller's). Furthermore, a a few shops like a book shop or a drug store are available (like Ako and Etos). Examples of this station type are Leeuwarden, Nijmegen and Haarlem.
	Very large	-The transfer station is a very large station with ten or more shops available to get something to eat or drink (for example Burger King, Starbucks, Julia's). Furthermore several shops with non-food articles are available (like Hema, Etos, Ako, Rituals). Examples of this station type are Amsterdam Centraal, Utrecht Centraal and Rotterdam Centraal.

3.4 Experiment design

This section describes the development of the experiment design. The experiment design includes all possible choice situations with the corresponding attribute levels which are presented to respondents.

3.4.1 Reducing the size of the experiment design

As described in the previous section, a total of 6 attributes, with 3 or 5 attribute levels, are included in this experiment. A full factorial design (a design with all possible combinations of attribute levels) would consist of $5^4 \cdot 3^2 = 5625$ different choice options. All types of effects can be studied with a full factorial design. Louviere et al. (2000, p. 94) distinguishes three types of effects:

- Main effects: The effect of a single attribute on the choice
- Two-way interaction effect: The effect of a combination of two attributes on the choice
- Higher order interaction effect: The effect of a combination of more than two attributes on the choice.

Since it is not possible to include such a large number of choice options into a choice experiment, a fractional factorial design (FFD) is used to reduce the number of choice options. In a FFD, only a fraction of all the possible choice options is included, implying a loss of information. However, when the selection of choice options to include is done carefully, it is still possible to estimate the main effects.

To obtain main effects, a design should be balanced and orthogonal (Huber & Zweringa, 1996; Kuhfeld, 2006; Sanko, 2001). A design is balanced when each attribute level occurs equally often within each attribute. A balanced design makes sure that there is equal precision in the estimates for all the utilities. A design is called orthogonal when every pair of levels occurs equally often across all pairs of factors, which ensures that estimates across factors are independent (Kuhfeld, 2006; Sanko, 2001). In this case, main effects are independent of one another, but not independent of two-way interactions (Louviere et al., 2000). The interaction effects which cannot be measured in a FFD will be assumed negligible since main effects explain often more than 80% of the amount of variance in response data (Louviere, 1988, as cited in Ortuzar & Willumsen, 2006).

3.4.2 Choice set creation

A sequential choice set creation is performed in a way described by (Louviere et al., 2000). One FFD is constructed in the first place, based on this FFD, a second statistically equivalent FFD is created. The choice options from both the FFD's are placed in two separate 'urns' and pairs are drawn without replacement to construct choice situations. By using two different FFD's, all combinations of two attribute levels occur in both alternatives. This is important since the alternatives can differ (BTM-train versus train-train). This process is described step-by-step below.

Step 1: Construction of FFD1

Kuhfeld (2005) provides an overview of all known designs which are both balanced and orthogonal up to 128 choice options. Unfortunately, no orthogonal balanced design exists for the specific combination of attributes and attribute levels of this experiment. This means that a design must be used in which the balanced and orthogonal criteria conflict with each other (Huber & Zweringa, 1996). The software program SPSS produces a design of 25 choice options which is completely orthogonal, but not balanced. This design is used as basis FFD. One choice option is removed from the basis FFD to end up with 24 choice options. This gives up the perfect orthogonality of the design but makes it possible to distribute all choice options evenly between respondents, since they will all receive 12 choice situations. The choice option which is removed is a choice option which least affects the orthogonality between attributes. Another consequence of the removal of one of the choice options is that the four attributes which contain 5 levels cannot be perfectly balanced. One attribute level will appear four times while the other attribute levels appear 5 times (thus these attributes will be nearly balanced). On the other hand, it is now possible to balance the two 3-level attributes (each level can appear 8 times). This is done in a way that the lowest possible correlations between attributes occur.

The described procedure resulted in a FFD which is nearly balanced and nearly orthogonal. The average correlation between attributes is only 0.03. In practice, it is still feasible to estimate all the parameters with designs that are nearly balanced and nearly orthogonal (Johnson et al., 2013).

Step 2: Construction of FFD2

A FFD which is statistically equivalent to FFD1 is created. This is done by a systematic rotation of the attribute columns. All 5-attribute level columns shift one place to the left and the two 3-attribute level columns are exchanged.

Step 3: Construct choice situations

The third step is to create choice situations by combining the choice options from FFD1 and FFD2. The choice options are placed in two separate 'urns' and pairs are drawn without replacement. Each attribute level is only meaningful in comparison with the attribute level of another option within a choice situation (Huber & Zweringa, 1996; Louviere et al., 2000). Therefore, the probability that an attribute level repeats itself within a choice situation should be as small as possible, this is called the minimal level overlap criterion (Huber & Zweringa, 1996; Louviere et al., 2000). Furthermore, dominant choices (all attributes levels within one alternative are unambiguously better than the attribute levels of the competing alternative) should be avoided as much as possible. Therefore, different designs arecreated to find the design which best fulfills these criteria.

It is not always possible to determine unambiguously when a choice is dominant. However, for the attributes access/egress trip time, in-vehicle train time, costs and headway, it is clear that a lower value of this attribute is preferred. The design with the least overlaps and the least dominant choices includes two overlaps and two dominant choices.

Step 4: Blocking the design into choice sets

Since the design consists of 24 choice situations and respondents are only presented 2 x 6 choice situations, the design is blocked into 4 blocks of 6 choice situations. Choice situations are randomly assigned to one of the blocks. The aim is to have a variation of attribute levels within each block as well, therefore some manual adjustments are made. Respondents are randomly assigned to two blocks (one block for each type of choice situation).

The described procedure resulted in the design of the choice experiment, which is added in appendix B.

3.4.3 Presentation to respondents

The choice situations are presented to respondents in a web-based survey. An example of a choice situation as presented to a respondent is shown in Figure 11. Each choice situations is presented on a new page to avoid the comparison of different choice situations by the respondent. A picture of the choice situation is added to give a clear overview of the possible alternatives. Furthermore, pictures of the BTM mode and train are added in the choice options.

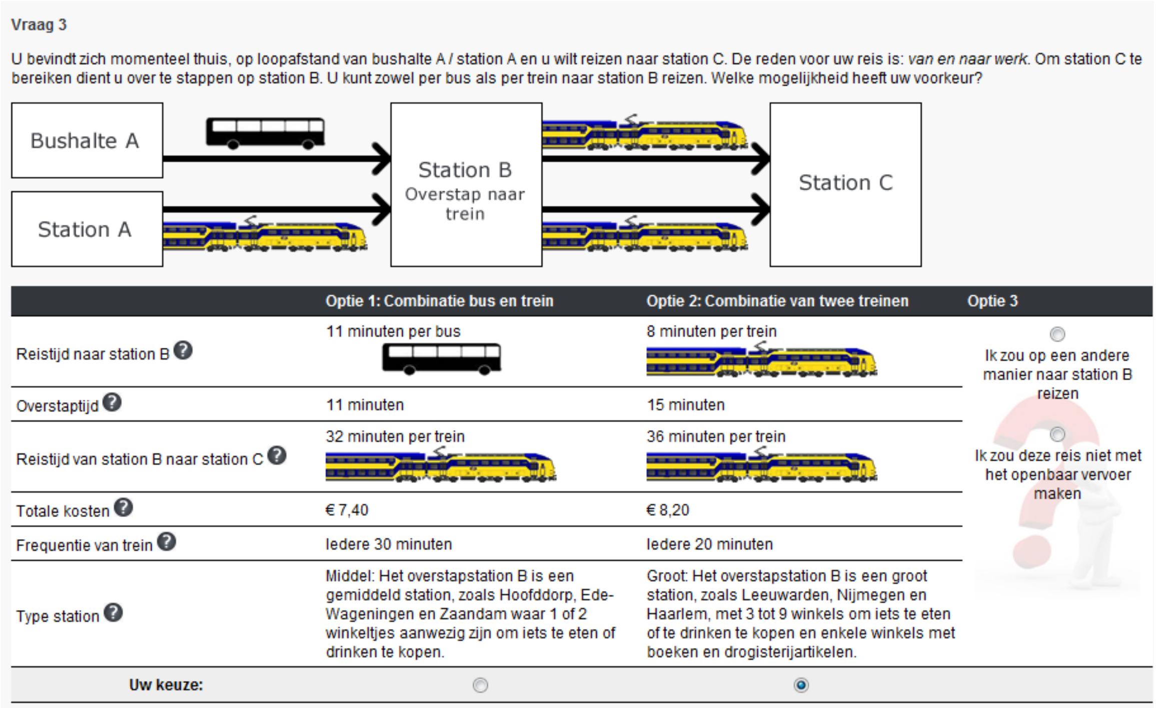


Figure 11: Example of a choice situation as presented to the respondents

3.5 Pilot survey

Before the data collection started, the survey is tested. The first test was performed among a small group of acquaintances. These tests resulted in the removal of technical errors, some additional answer options and several textual changes in questions and answer options.

The next test phase was a pilot survey among 100 NS panel members. Of this group, 39 respondents completed the entire survey. Another 20 respondents started the survey, but did not complete all the questions. For this group, it is checked at which point they quit the survey. 3 respondents were not able to complete the survey because they were ejected from the survey by the selection questions, 6 respondents stopped the survey in one of the questions before the SP experiment. 5 respondents stopped after the explanation of the SP experiment. Another 6 respondents quit the survey during one of the SP questions. Pictures were added to the page with the SP explanation to make this page more attractive and easier to read.

A textbox was present at each page where the respondents had the option to make comments about the page. These text boxes were mostly used to explain the given answers. For example “transfer time is very important for me”. In a few cases, a technical error was indicated. These errors are all fixed. For questions with an “other namely” option, the answers on this option were manually checked. If multiple respondents indicated the same “other namely” description, this was added as an extra answer option. Since only minor textual changes are made to the survey after the pilot, the 39 respondents from the pilot are included in final dataset.

4. Data collection

This chapter elaborates on the data collection process. The first section describes the recruitment of the respondents. The second section is concerned with the process of removing unreliable respondents based on objective criteria. The third section provides some descriptive statistics on the resulting data set.

4.1 Recruitment of respondents

The sampling frame consists of members of the NS panel. The NS panel is a panel which consists of train travelers who agreed to participate in several surveys conducted by NS. Most of these panel members completed an entry survey with general questions about their socio-demographic characteristics and travel characteristics. To ensure that the respondents could describe a recent trip where they used BTM as access or egress mode, respondents were only selected if they indicated in the entry survey that their most used access and/or egress mode is BTM.

Since the choice situations describe a situation where a transfer occurs at a type 1, 2 or 3 station, it would be best to select only respondents who normally use such a station. However, from only 40% of the respondents included in the NS panel, the regular origin station and destination station is known. 90% of the respondents from this group had an origin station or destination station from station type 1, 2, or 3. Excluding all respondents with unknown origin or destination station would have led to a large loss of respondents while almost all of the respondents will use a station of type 1, 2 or 3 in their trip. Therefore, this selection criterion is not applied.

4.1.1 Target sample size

It was expected that the most important differences in perceived utilities occur for different trip motives and travel frequencies. Three different trip motives are distinguished in advance: work/business, school/study and social/recreational/other. Furthermore, three groups of travel frequencies are distinguished: once per week or more, 1-3 times a month and once a month or less. Respondents either participated in the access SP experiment or in the egress SP experiment (as described in section 3.2.2). This means that $2 \cdot (3 + 3) = 12$ different segments exist. There is however overlap since a respondent will belong to two groups (one for trip motive and one for travel frequency).

Ortuzar and Willumsen (2006) propose rules of thumb for the sample size in SP experiments. They suggest that 75-100 respondents per segment would be appropriate. Therefore the target amount is set to 100 respondents per group. An overview of the target sample size per segment is given in Table 9. A requirement for all respondents is that they can recall at least one train trip where BTM was used as access- or egress mode. With these amounts of respondents per segment, it was expected feasible to estimate separate models for the different groups.

Table 9: Overview of target net amount of respondents per segment

	Access	Egress	Total
Trip motive			
Work/business	100	100	200
School/study	100	100	200
Social/recreational/other	100	100	200
Travel frequency			
Once per week or more	100	100	200
1-3 times a month	100	100	200
Less than once a month	100	100	200

4.1.2 Gross sample size

After the pilot with 100 panel members, 3147 new panel members are invited. The invitation is sent in a few batches at the end of May and the beginning of June 2014. The amount of respondents with trip motive school/study turned out to be very low, therefore a reminder is send to the non-respondents in this group. A total of 1348 respondents completed the survey. 203 respondents were excluded after the entry questions since they indicated that they could not indicate a train trip where they used BTM as an access or egress mode. This resulted in a sample size of 1145 respondents (response rate of 35.3%) who answered all the questions. No checks on the validity of the answers are performed yet. This procedure is described in section 4.2.

4.2 Exclusion of respondents

The choices of the 1145 respondents who completed the full survey are checked with the aim to eliminate respondents from the dataset who did not answer the questions seriously. The criteria to exclude respondents are summed up below. These criteria are executed in consecutive order. Appendix C shows the distribution of values for the different exclusion criteria.

Survey completion time

A certain amount of time is needed to answer all the survey questions seriously. For all respondents, the total time to complete the survey is registered. Furthermore, the time to complete the SP experiment within the survey is registered. The time to answer all the choice situations in the SP experiment can be very short when a respondent is very sensitive to one of the attributes (for example always choses the alternative with the lowest costs). However, the minimum time to read the explanation of the experiments and answer the choice situations seriously is set on 1 minute and 30 seconds. A graph which shows the distribution of the time that the respondents needed for the SP experiment is included in appendix C. It can be observed that there are a lot more respondents in the group between 01:30 – 02:00 minutes than the lower groups.

Furthermore, the time to complete the total survey is set on 5 minutes. This is quite short, but possible since some of the questions are standard questions for NS surveys (for example questions about travel frequency and trip motive), which are familiar to respondents. Again, appendix C shows the distribution of the time needed. A clear rise of respondents is seen in the group which needed 5 to 6 minutes. These two criteria led to an exclusion of 9 respondents.

Unrealistic cost estimations

The minimum fare for a one-way train ticket in the Netherlands (second-class with discount) is €1,30 and the maximum fare for a one-way ticket in the Netherlands is around €60 (first-class without discount with multiple carriers). It is important that the costs estimation is realistic, since it is input for the SP experiment. Therefore, respondents with a cost estimation outside this possible range are excluded from the dataset. This criterion led to an exclusion of 24 respondents.

The minimum fare for a one-way BTM ticket (with discount) is around €0,50. The maximum fare for a one way BTM-ticket is unknown, but costs above €10 are considered highly unlikely. For the same reasons as the costs estimation of the train trip, respondents with an estimation outside this range are excluded from the data. This criterion led to an exclusion of 21 respondents.

Unrealistic trip time estimations

The estimated trip times are input for the SP experiment as well. Therefore it is important that these values are realistic. The estimated BTM trip time cannot exceed 60 minutes, since it is unlikely that a BTM trip of more than 60 minutes is an access or egress trip for a train trip. This criterion led to an exclusion of 3 respondents.

Trip times of 5 minutes or lower for train trips are possible, but very rare. Therefore, they are excluded when the real average trip time for the indicated trip is 30 minutes or more (13 exclusions). Furthermore, train trips of 5 hours or more are highly unusual within the Netherlands and are also excluded (4 exclusions).

Comments

Two respondent indicated in the comments section that they randomly selected some options in the SP experiment. Therefore these respondent are excluded from the dataset.

Table 10 below shows the amount of respondents that are excluded after each of the above mentioned criteria is applied in consecutive order. A total of 81 respondents are excluded which leads to a net sample size of 1064 respondents.

Table 10: Overview of exclusion of respondents per category

Exclusion criterion	Respondents excluded	Respondents left in dataset (original 1145)
Completion time SP experiment < 01:30	5	1140
Total survey completion time < 5 minutes	4	1136
Unrealistic cost estimations train trip	29	1107
Unrealistic cost estimation BTM trip	21	1086
Unrealistic trip time estimation BTM trip	3	1083
Unrealistic trip time estimation train trip	17	1066
Comments	2	1064
Total	81	1064

4.3 Descriptive statistics

This section provides some descriptive statistics of the dataset, after the application of the exclusion criteria described in the previous section. An extensive overview with more sample characteristics is included in appendix D.

4.3.1 Distribution of trip motive and travel frequency

Table 11 shows the distribution of respondents per trip motive and travel frequency. Furthermore, the real-world distribution of the trip motives and travel frequencies within the NS population is given. As described in section 4.1.1, it was planned to take the trip motives social, recreational and other together as one trip motive. However, a very high amount of respondents is present in this group, which allows to make a distinction between social and recreational/other. All segments, except the trip motive school/study met the target sample size of 100 respondents.

The real-world distribution as presented in Table 11 is based on internal data (Climate IV) by NS. This is a large research which is conducted every few years by NS to obtain insights into the characteristics of the train travelers. The research is based on approximately 16000 respondents, both from NS panel and other sources. Since this is the largest research available on the characteristics of travelers, this is considered as the real-world distribution.

The trip motives work/business and school/study are underrepresented in the sample while the trip motives social and recreational/other are overrepresented. For travel frequencies, the category 'once per week or more' is underrepresented in the sample and '1-3 times a month' and 'less than once a month' are underrepresented.

Table 11: Distribution of trip motive and travel frequency of respondents in the final dataset

	Access		Egress		Total		NS population (trips 2010)
	Absolute	%	Absolute	%	Absolute	%	%
Trip motive							
Work/business	177	34%	184	34%	361	34%	45%
School/Study	39	8%	44	8%	83	8%	31%
Social	155	30%	186	34%	341	32%	11%
Recreational/other	144	28%	135	25%	279	26%	13%
Travel frequency							
Once a week or more	244	47%	291	53%	535	50%	77%
1-3 times a month	129	25%	139	25%	268	25%	10%
Less than once a month	142	28%	119	22%	261	25%	13%

Table 12 shows the cross tabulation of the trip motives and travel frequencies in the sample. The majority of the respondents with trip motive work/business or school/study have a travel frequency of once a week or more. Respondents with trip motive social are quite evenly distributed among the different travel frequencies. Trip motive recreational/other consists of more infrequent travelers.

Table 12: Cross tabulation of trip motive and travel frequency of sample

	Work/business		School/study		Social		Recreational/other	
Travel frequency	Absolute	%	Absolute	%	Absolute	%	Absolute	%
Once a week or more	306	28.8%	66	6.2%	115	10.8%	48	4.5%
1-3 times a month	36	3.4%	10	0.9%	123	11.6%	99	9.3%
Less than once a month	19	1.8%	7	0.7%	103	9.7%	132	12.4%

4.3.2 BTM use

Respondents are asked how often they use BTM as access and egress mode for train trips. Four answer options were possible: (almost) never, sometimes, often and (almost) always. The results are shown in Table 13. The table shows that the frequency of BTM use is higher in the egress trips than the access trips. Internal research by NS also shows a higher share of BTM use for egress trips than for access trips.

Table 13: Use of BTM as access or egress mode for a train trip

Use of BTM as access/egress mode	Access		Egress	
	Absolute	%	Absolute	%
(Almost) never	344	32%	134	13%
Sometimes	166	16%	288	27%
Often	169	16%	270	25%
(Almost) always	385	36%	372	35%

Table 14 shows the distribution of the separate modes bus, tram and metro in the reported RP trips. The bus is used by the largest part of the respondents. The share of the bus is higher for access trips than for egress trips. No real-world data is available on the use of BTM, distinguished by mode. Therefore a comparison cannot be made.

Table 14: Distribution of bus, tram and metro in sample

Mode	Total		Access trips		Egress trips	
	Absolute	%	Absolute	%	Absolute	%
Bus	616	58%	356	69%	260	47%
Tram	275	26%	94	18%	181	33%
Metro	173	16%	65	13%	108	20%

4.3.3 Attribute values of RP trip

Respondents are asked to indicate a trip made by train, with BTM as access and/or egress mode. Since this is an actual trip, it can be considered as an RP observation. All the values of attributes which are used in the SP experiment are asked for the RP trip as well. Table 15 shows the average value and the standard deviation for the quantitative attributes in the RP trip. Table 16 shows for each station type the amount of respondents which used such a station as transfer station between BTM and train.

Table 15: Statistics on RP trips respondents

Attribute	Average	Standard deviation
Access/egress trip time total (minutes)	15.2	8.9
Access/egress trip time bus (minutes)	16.1	9.3
Access/egress trip time tram (minutes)	15.3	7.5
Access/egress trip time metro (minutes)	11.8	8.3
In-train time (minutes)	67.1	47.8
Transfer time (minutes)	9.5	7.3
Headway of connecting mode (minutes)	19.5	12.0
Costs BTM trip (euro)	1.80	1.01
Costs train trip (euro)	10.29	6.78

Table 16: Amount of respondents per station type

Station type	N	Percentage
1	456	43%
2	324	30%
3	168	16%
4	66	6%
5	29	3%
6	21	2%

The access/egress trip time, in-train time and the costs are used as input for the attribute values in the SP experiment and are therefore automatically within a close range of the experience of a respondent. The values for transfer time, headway of the connecting mode and station facilities are fixed values and therefore not dependent on the input of the respondent (as described in section 3.3.2).

The transfer time of the respondents has an average value of 9.5 minutes. Within the SP experiment, the middle level is 8 minutes. The middle level for headway of connecting mode is 20 minutes in the SP experiment, which is very close to the average RP value of 19.5 minutes. For the station facilities, 89.2% used a station of type 1, 2 or 3 as a transfer station. These station types are comparable with the descriptions of the medium, large and very large stations in the SP experiment. The average values of the RP trip show that the attribute levels within the SP experiment are all within a close range of the actual experience of a respondent.

5. Data analysis

The first section of this chapter describes the model estimation procedure. The second section discusses the resulting parameter values. In the third section, analyses on other survey data are discussed.

5.1 Model estimation

The model estimation consists of several steps, starting with a simple model. Step by step new additions are tested. The main steps which are performed to estimate the final models are summed up below.

- Estimation of a basic MNL model.
- Test whether the attributes are generic or alternative-specific
- Test performance of different sub models with a segmentation based on trip motive, travel frequency or trip stage
- Test the effect of socioeconomic and trip characteristics
- Test the effect of station assessments
- Apply weighting
- Test the effect of scale parameters
- Test mixed logit model to account for panel effect
- Estimate sub models with final model specifications

The steps described above are generally executed in a consecutive order, but iterations took place as well. The next sections describe each step in more detail.

5.1.1 Basic multinomial logit model

The first estimated model is a basic MNL model. This model includes all the attributes from the SP experiment design. The access/egress trip time, in-train time and the costs are modeled as a linear function since these were continuous variables. The transfer time, headway and station type are modeled with dummy variables since only predefined discrete values are used. Furthermore, an alternative-specific constant (ASC) is added to express the relative preference for a train-train alternative compared to a BTM-train alternative.

In this model, access/egress trip time, in-train time, costs and larger headway parameters are all significant and have a negative value (which was expected a priori). Transfer times below or above 8 minutes are also perceived negative, compared to a transfer time of 8 minutes. This is in accordance with one of the survey questions (question 18, see appendix A) where respondents were asked about their preferred transfer time for a transfer between BTM and train. The average value derived from this question was 7.7 minutes. The dummy parameters for a large station and a very large station are not significantly different from the fixed parameter for a medium station. However, a very large station is valued significantly different from a large station. Therefore, a new model is constructed with a distinction between two station sizes (medium/large and very large) instead of three station sizes.

5.1.2 MNL model with alternative specific attributes

The basic MNL model described in the previous section is the starting point for the next step. In the basic model each attribute was modeled as a generic attribute. This means that it was assumed that an attribute is valued equally in the BTM-train alternative and the train-train alternative. Therefore only one parameter for each attribute was estimated. To test whether or not an attribute is alternative specific, two parameters are estimated for each attribute (one for the BTM-train alternative and one for the train-train alternative) in a consecutive order.

The likelihood ratio test (as described in section 2.3.3) is used to test if the model with alternative specific attributes is performing better.

The valuation of transfer time turns out to be alternative specific. Therefore a new model is constructed where a distinction is made between transfer time in a BTM-train transfer and a train-train transfer. For all the other attributes, the model was not performing better with alternative-specific attributes. Therefore, these attributes are kept generic.

In 5.65% of the choice situations, one of the no-choice options was chosen. The no choice options are difficult to include in the model. Since respondents are presented choices with attributes based on their RP trip, there are large differences in attribute values between respondents and a valid model including the no-choice options cannot be identified. The aim of this study is to quantify the different elements influencing the transfer disutility of a BTM-train transfer and make a comparison with a train-train transfer. The no-choice options do not provide extra information on the relative importance of the attributes. Therefore, the no-choice options are not included in the model.

5.1.3 Estimation of separate MNL models

Trip characteristics and socioeconomic characteristics are expected to influence the parameter values. As discussed in section 4.1.1 it is expected that large differences occur for different trip motives and travel frequencies. Furthermore, differences might occur dependent on whether the respondent was presented an access trip or an egress trip by BTM. The model from the previous section is separated into different models for trip motive, travel frequency and access or egress experiment. Table 17 shows the value of the adjusted ρ^2 for each separate model. As discussed in 2.3.2, the adjusted ρ^2 value is a measure for the goodness of fit of the model, where a higher value means a better model fit.

Table 17: Values of adjusted ρ^2 for separate models

Separate models by	Adjusted ρ^2	Respondents
Trip motive		
Work/business	0.193	361
School/study	0.209	83
Social	0.157	341
Recreational/other	0.145	279
Travel frequency		
Once a week or more	0.196	535
1-3 days a month	0.135	268
Less than once a month	0.129	261
Trip stage		
Access	0.139	515
Egress	0.163	549

A distinction by trip motive yields the highest values for the adjusted ρ^2. For each type of separation (trip motive, frequency, trip stage), the parameters in the separate models are compared with each other to determine which parameters are significantly different (confidence interval 95%) from each other. The largest differences are observed with a distinction by trip motive. Since this distinction also resulted in the highest values for the adjusted ρ^2, the next modelling steps will be based on the differentiation by trip motives. The model for travelers with a travel frequency of once per week or more yields a high value for the adjusted ρ^2 as well. This frequency is correlated with trip motive work/business as is shown in section 4.3.1.

5.1.4 Socioeconomic and trip characteristics

A large variety of socioeconomic and trip characteristics of the respondents are tested on systematic taste variations. For each characteristic which is tested, a new model is estimated for the general model and for the models with distinctions by trip motive. It is checked if the parameter is significant and whether or not the new models are performing significantly better than the previous models according to the likelihood-ratio test (as discussed in section 2.3.3). This was an iterative procedure which is repeated until all hypothesized characteristics were tested. Access/egress trip time, transfer time, in-train time and costs are found to be dependent on socioeconomic and trip characteristics. Below is an overview of the characteristics which are found to have a significant effect.

BTM trip time

Different parameters for bus and tram/metro led to a significant model improvement. Furthermore, a difference is found between access and egress trips. Therefore, the parameter for access/egress trip time is split up into four parameters:

- Access time by bus
- Access time by tram or metro
- Egress time by bus
- Egress time by tram or metro.

Transfer time

Since the transfer time exists of five dummy variables (3, 5, 8, 11, 15 minutes), the effects of socioeconomic characteristics can be tested on each value for transfer time separately. The utility of a transfer time of 3 or 5 minutes is valued significantly higher by people with a high travel frequency (once a week or more). Furthermore, the utility of a transfer time of 3 minutes is found to be influenced significantly by age. People of 60 years or older value such a short transfer time significantly worse. This results in 3 extra parameters

- Positive parameters for a transfer time of 3 and 5 minutes if people travel once a week or more by train
- Negative parameter for a transfer time of 3 minutes if people are 60 years or older

In-train time

The sensitivity for in-train time is found to be dependent on the total train time. For longer train trips, respondents are relatively less sensitive for the in-train time. Therefore in-train travel time is included in the model piecewise linear. The function for the utility of in-train time is composed of two linear functions, one for an in-train time of 90 minutes or less and one for an in-train time of more than 90 minutes. Other breakpoints and multiple breakpoints did not increase the performance of the model. Trips with an in-train time of more than 90 minutes are reported by 29% of the respondents.

Costs

The sensitivity to costs is found to be dependent on a combination of the following two characteristics:

- Whether or not the respondent paid for the RP trip himself
- Income group

Eight different income categories are distinguished in the answer options. Some income groups are grouped together since the models did not perform significantly better when these income groups were distinguished, according to the likelihood ratio test. The following income groups are distinguished in the models (gross income monthly per person):

- less than €2000,
- €2000 - €3000 and unknown,
- €3000 - €6000
- more than €6000.

Combined with two options for the payment (self or other), this led to 8 different parameters for costs.

5.1.5 Station assessments

Respondents assessed six station aspects in the survey. These assessments are based on the station used in the RP trip, while the SP experiment presented hypothetical situations without station names. It could however be possible that a respondent still had his specific station in mind when answering the SP questions.

For each assessed aspect, it is tested whether or not this influences the preference for one of the two alternatives. This is done by adding an extra parameter to the model with the assessment of that aspect as attribute value. None of the parameters were found significant. Furthermore, it is tested if there is a difference in the valuation of the attributes within an alternative for sufficient assessments (6 or higher) and insufficient assessments (5 or lower). The tests are performed on the attributes for transfer time, headway and station facilities. For none of the assessed aspects of the actual used station, a significant effect is found in the valuation of the above mentioned attributes. Therefore, the assessment of the station is not included in the models. Section 5.3.3 reports further on the station assessments.

5.1.6 Weighting

As shown in section 4.3, the distribution of trip motives among the respondents of the survey is not representative for the NS population. Since the trip motive highly affects the perceived utility, a weighting is applied to compensate for the unrepresentative distribution of trip motive when a general model is estimated. Table 18 shows the weighting factors based on trip motive. Since the trip motive school/study is heavily underrepresented, a relatively high weighting factor is applied (3.97). This group is quite homogeneous in several aspects (travel frequency, income, age, education) and therefore, this factor is still acceptable. With the weighting on trip motive, the distribution of travel frequencies is close to the real-world distribution as well. Therefore no further weighting on frequency is applied.

Table 18: Distribution of trip motive compared to distribution among NS population with resulting weighting factor

Trip motive indicated trip	Amount of respondents	Unweighted distribution	Distribution among NS population (trips)	Weighting factor
Work/business	177	34%	45%	1.33
School/Study	39	8%	31%	3.97
Social	155	30%	11%	0.34
Recreational/other	144	28%	13%	0.50

With the weighted model, the adjusted ρ^2 increases from 0.172 to 0.192, which means that the model fit is increased. Small changes are observed in the parameter values. The valuation of egress time by bus decreases with a value of 1.56 to 1.39 minutes generalized travel time. Furthermore, small changes occur at the valuation of BTM-train transfer time. For the weighted model, the disutility for a transfer time of 3 minutes compared with the unweighted model, while the disutility for a transfer time of 11 and 15 minutes is larger. This could mean that respondents with trip motive work/business or school/study (which are now more important due to the weighting factor) award less disutility to small transfer times and in-vehicle time by bus.

Another interesting result is that the parameter value for a very large transfer station was significant in the unweighted model, but became insignificant (t-test 1.61) after the weighting is applied. This means that the type of station is more important for social and recreational travelers (which are less important in the weighted model due to the weighting factor). Furthermore, the piecewise linear parameter for train trips of more than 90 minutes became insignificant. This is probably due to the large amount of these long-distance trips within the social and recreational travelers.

5.1.7 Scale parameters

In the previous sections, it was assumed that the error component ε_{iq} is independently, identically distributed extreme value over alternatives and people (as explained in 2.3.1). However, such an error can vary over data sets, between alternatives, time periods, decision contexts or other factors for the same individual (Louviere et al., 2000, p. 139; Train, 2009, p. 26). To account for this variance, a scale parameter λ can be added to the model, resulting in the following choice probabilities

$$P_{iq} = \frac{e^{\lambda_{k,1} V_{iq}}}{\sum_{j=1}^{N} e^{\lambda_k V_{jq}}} \quad \textit{(Equation 15)}$$

With λ_k the scale parameter belonging to the specific group k (k_1, k_2, …k_t). This coefficient indicates the effect of each observed variable relative to the variance of unobserved factors. A larger variance in unobserved factors leads to smaller coefficients (Train, 2009, p. 41). Each respondent is presented two types of choice situations (choice between two BTM-train transfers and a choice between a BTM-train and a train-train transfer). The scale difference between these two choice types was insignificant, meaning that it is appropriate to combine both types of observations in one dataset.

A large variety of other scale parameters is tested as well, including scale parameters based on BTM mode, trip stage and RP characteristics. The largest scale difference in the general model is found between respondents who had an in-train time of less than 70 minutes in their RP trip, compared with respondents who had an in-train time of more than 70 minutes. Other specifications with different parameters and more thresholds are tried as well, but the results were less significant. With the scale of a trip less than 70 minutes fixed by 1, the scale parameter for a trip of more than 70 minutes is 0.659 (with a standard error of 0.0414 and a t-test value of -8.24).

5.1.8 Mixed logit models

To account for the panel effect (as is explained in section 2.3.4) error components are added to the final models to estimate a mixed logit model. An error component with a normal distribution is added to each utility function (the error component for one of the utility functions is fixed to 0). These error components vary over respondents, but not over different observations within one respondent.

Simulation with a large number of draws is performed to estimate the parameter values for the mixed logit models. When using pseudo-random numbers at least 1000 draws are recommended in literature. However according to Train (1999), when using Halton sequences, the same accuracy is achieved with 125 draws compared to 2000 pseudo-random draws. Therefore 125 Halton draws are used. To test the sensitivity of the results on the number of draws, the general model is also estimated with 500 Halton draws. Considerably longer estimation times were needed, while the obtained parameter values were almost equal to the parameter values obtained with 125 Halton draws (differences of less than 1%). Therefore, the models are estimated using 125 Halton draws.

Unfortunately, Biogeme is not able to simultaneously estimate scale parameters (as discussed in the previous section) and the error-components in one model. Therefore, a two-step procedure, as explained by Arentze and Molin (2013) is used. The first step is to estimate the scale parameters in a MNL model. For the second-step estimation, the obtained scale estimates are used to rescale the attribute variables in each observation. Based on the rescaled attributes, an error component ML model can be estimated. This procedure might result in a slight underestimation of the standard errors (Arentze & Molin, 2013). Therefore, parameter values with a t-test just over 1.96 should be interpreted with care.

The error component of one of the BTM-train utility functions is normalized to zero. The error component of the other BTM-train utility function was not significantly different. This is a logical result, since these utility functions are built up in exactly the same way. Therefore, the preference within a person should be equal. The error component of the train-train utility function was significantly different. Changing the fixed error component to another utility function gives comparable results. According to the likelihood ratio test, the mixed logit model performs better than the MNL model. The parameters in the ML model are larger than in the MNL model, which is in line with theoretical expectations (Navarette & Ortuzar, 2013). The results of the final general weighted ML model are presented in Table 19 below.

Table 19: Parameter estimates with the final weighted mixed logit specification

	General model			
Parameter	Value	Std error	t-test	GTT
ASC BTM-Train	-0.256	0.118	-2.18	4.7
ASC train-train	0	fixed		
Access time by bus	-0.0629	0.00549	-11.45	1.2
Egress time by bus	-0.0749	0.00592	-12.65	1.4
Access time by tram/metro	-0.0454	0.00841	-5.41	0.8
Egress time by tram/metro	-0.0421	0.00752	-5.6	0.8
Costs, someone else pays, income < €2000	-0.362	0.02	-18.14	6.7
Costs, someone else pays, income €2000 - €3000	-0.174	0.043	-4.05	3.2
Costs, someone else pays, income €3000 - €6000	-0.179	0.0174	-10.34	3.3
Costs, someone else pays, income > €6000	-0.05	0.0305	-1.64*	0.9
Costs, traveler pays, income < €2000	-0.647	0.0313	-20.69	12
Costs, traveler pays, income €2000 - €3000	-0.46	0.0365	-12.62	8.5
Costs, traveler pays, income €3000 - €6000	-0.315	0.0203	-15.54	5.8
Costs, traveler pays, income > €6000	-0.114	0.0442	-2.57	2.1
Headway connecting mode 15 minutes	0	fixed		
Headway connecting mode 20 minutes	-0.308	0.0357	-8.61	5.7
Headway connecting mode 30 minutes	-0.593	0.0376	-15.77	11
In-train time	-0.054	0.00292	-18.51	1
Extra parameter in-train time > 90 minutes	0.00057	0.00392	0.14	0
Transfer station medium/large	0	fixed		
Transfer station very large	0.0447	0.0309	1.45*	-0.8
Transfer time of 3 minutes BTM-train	-0.427	0.0922	-4.64	7.9
Transfer time of 5 minutes BTM-train	-0.385	0.0867	-4.44	7.1
Transfer time of 8 minutes BTM-train	0	fixed		
Transfer time of 11 minutes BTM-train	-0.7	0.0617	-11.34	13
Transfer time of 15 minutes BTM-train	-1.02	0.0616	-16.61	18.9
Transfer time of 3 minutes train-train	-0.466	0.136	-3.43	8.6
Transfer time of 5 minutes train-train	-0.35	0.131	-2.67	6.5
Transfer time of 8 minutes train-train	0	fixed		
Transfer time of 11 minutes train-train	-0.593	0.117	-5.08	11
Transfer time of 15 minutes train-train	-1.24	0.117	-10.64	23
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.421	0.091	-4.63	7.8
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.411	0.0867	4.74	-7.6
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.358	0.0843	4.25	-6.6
Sigma BTM-train	0.006	0.083	0.07*	
Sigma train-train	0.795	0.0533	14.92	
Scale parameter in-train time RP trip < 70 minutes	1	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.659	0.041	-8.24	
Null log-likelihood	-8331.24			
Final log-likelihood	-6621.04			
Adjusted ρ^2	0.202			

* = insignificant result

5.1.9 Estimation results of sub models

Besides the general model presented in the previous section, different sub models are estimated as well. For these models, the same model specification is used, but only a selection of the respondents is included in the dataset on which the parameter values are estimated. Models are estimated based on trip motive, travel frequency, BTM mode and transfer station. Furthermore, models are estimated with the distinctions mentioned above in combination with a distinction by access/egress trip. Figure 12 provides an overview of the different estimated models. The resulting parameter values are included in appendix E. These different distinctions lead in some cases to very small sample sized and therefore less reliable models. Some of the parameters which are significant in the general model became insignificant due to the small amount of observations.

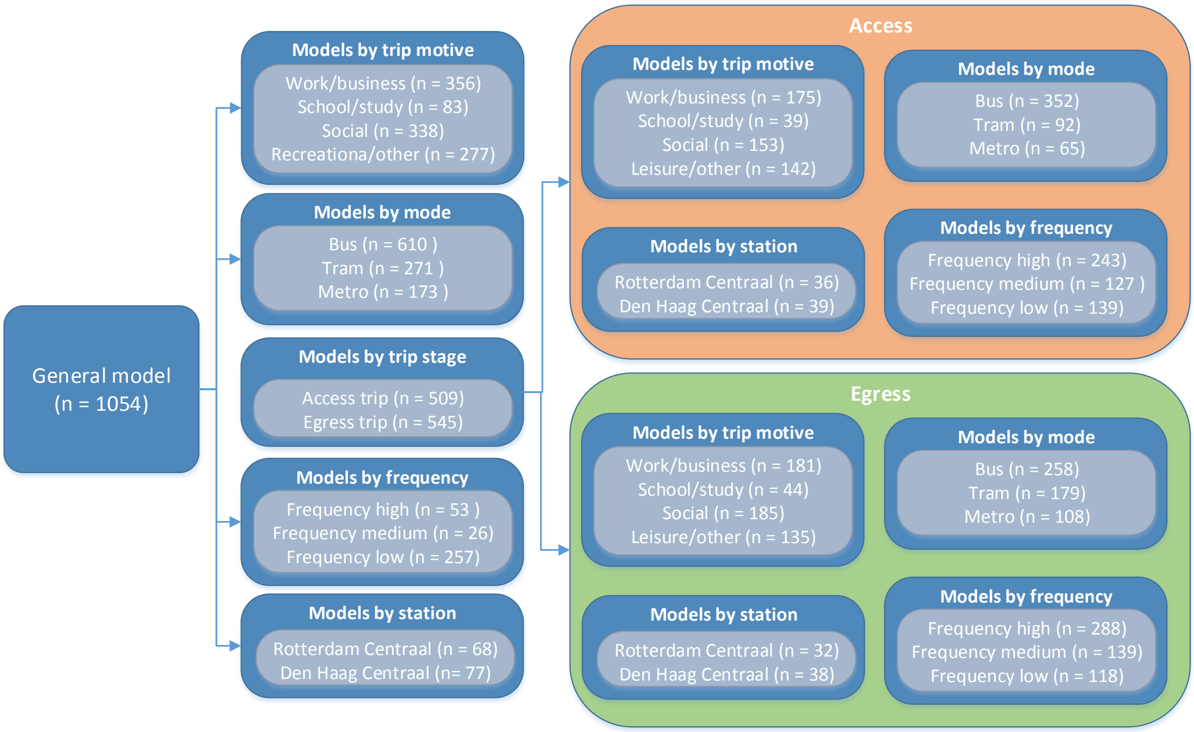


Figure 12: Overview of estimated sub models

5.1.10 Goodness of fit

For each estimated model, the value of the adjusted ρ^2 is given as well. This is a measure for the goodness of fit of the model, as is explained in section 2.3.2. A higher value means a better model fit, but there is no intuitive interpretation of the values. Values of adjusted ρ^2 between 0.2 and 0.4 are considered to be indicative of extremely good model fits (Louviere et al., 2000, p. 54). The general model has an adjusted ρ^2 of 0.202 which is considered as good. The access model has a value of 0.187 and the egress model has a value of 0.224, which means that the model fit is better for the egress model. Large differences occur for the models distinguished by frequency: 0.232 for the high-frequent travelers and only 0.151 and 0.147 for the medium and low-frequent travelers, meaning that the model fit is better for the high-frequent travelers.

5.2 Model results

The resulting models are not in all cases straightforward to interpret. Therefore, this section explains how the different parameter values can be interpreted. If possible, the obtained results are compared with literature to assess the validity of the models. Since there is a large variety of models, only the most important results are included in this section. When the general model is mentioned, this refers to the final model specification as presented in the previous section in Table 19.

The generalized travel time (GTT) is used to present the results (see for more information on the concept of generalized travel time section 2.2.1). The values of GTT are obtained by dividing each parameter value by the parameter value for in-train time. Therefore all attributes causing disutility are expressed in in-train minutes. For continuous variables, this means that the unit of measurement should be multiplied by the GTT value to obtain the total disutility for this attribute. For the dummy variables, the GTT values can be interpreted as a penalty if this situation occurs. This penalty is relative to the reference value which is fixed to zero. For example a transfer time of 5 minutes in a BTM-train transfer is perceived with a disutility of 7.1 minutes GTT, compared to a transfer time of 8 minutes. A traveler would thus be willing to accept an increased in-train time of 7.1 minutes to have a transfer time of 8 minutes instead of 5 minutes, according to this model. This concept of presenting results in generalized costs (in time or monetary units) is applied in several similar studies (Arentze & Molin, 2013; Haarsman, 2012; Navarette & Ortuzar, 2013)

5.2.1 Alternative-specific constant

The alternative-specific constant for the BTM-train alternative has a value of 4.7 minutes generalized travel time in the general model. This means that in this model, there is a base preference for the train-train alternative above a BTM-train alternative. In general, travelers are willing to spend 4.7 minutes more travel time to have a train-train trip instead of a BTM-train trip if all other attributes are equal.

With a segmentation between access and egress trips (thus BTM to train transfer versus train to BTM transfer, appendix E4), the alternative-specific constant for the BTM-train alternative has a value of 7.3 minutes for the access transfers. For the egress transfer, the obtained value is insignificant. This means that a transfer from BTM to train is perceived worse than a transfer from train to BTM. A possible explanation of this difference is that a transfer from BTM to train occurs less than a transfer from train to BTM, as is shown in section 4.3.2. In the models with further distinctions (appendix E7 – E13), the value for the alternative-specific constant became insignificant. This could be caused by the lower amount of respondents in these models.

5.2.2 Access/egress trip time

Four different parameters are distinguished for the access/egress trip time by BTM in the general model. Figure 13 shows the marginal value of access/egress time, both the estimates of the general model and a distinction by trip motive (appendix E2) are included. A distinction by travel frequency (appendix E5) is shown in Figure 14. The figures clearly show that time in the bus is perceived worse than time in the train (a factor 1.1 to 1.8, dependent on the trip motive and trip stage). Arentze and Molin (2013) find a factor of 1.15 to 1.4, which means that the obtained results in this model are on the high side in some occasions. A clear distinction can be observed between access trips and egress trips by bus. Egress trips are perceived worse than access trips.

The figures show differences in the valuation for access/egress time, however due to the standard errors, not all parameter values are significantly different from the parameter value of the in-train time. For the general model, the parameter values for bus egress time and tram/metro access and egress time are not significantly different from the parameter value for in-train time.

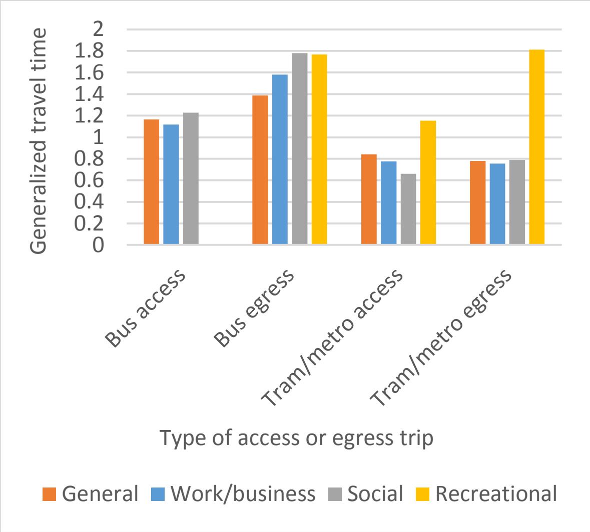


Figure 13: Disutility of a minute access/egress time by trip motive

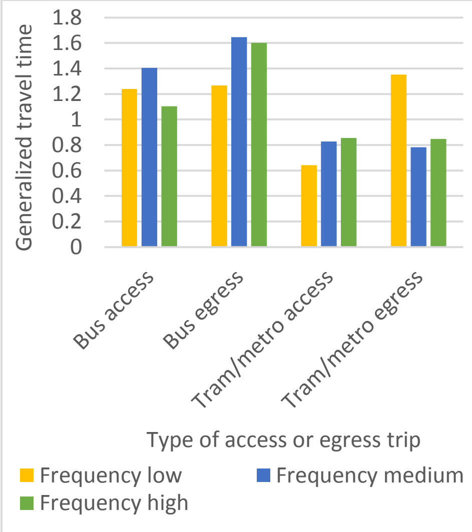


Figure 14: Disutility of a minute access/egress time by frequency

5.2.3 Costs

Eight different parameters are distinguished to express the disutility of costs. These parameters are based on income groups and whether or not the respondents paid for the train trip himself in the RP trip. When a respondent did not pay for the train trip himself in the RP trip, the costs attribute is far less important in all models, which indicates that the respondents assumed that they did not have to pay in the hypothetical choice situations either. A clear income effect is present, with decreasing importance of costs for higher income groups. Travelers with trip motive work/business are less-sensitive to costs than other travelers. This result is in accordance with literature.

With the valuation of costs, expressed in time, the value of time can be calculated. The value of time (VOT) is the amount of money that a traveler would pay to save an amount of time. The costs presented in the SP experiment were the total costs for the whole trip, no distinction between BTM costs and train costs is made. Since the largest part of these costs consist of train costs, the cost parameters will be used to calculate the value of time for the train. The values of time for the different trip motives and income groups are shown in Table 20. The trip motive school/study and the income group > €6000 are excluded from the table since the amount of observations in these groups is too low to obtain reliable results.

Table 20: Overview of VOT per income category and trip motive (in euro per person per hour)

Model	Estimation of VOT per income category (gross monthly)					
	<€2000	N	€2000-€3000	N	€3000-€6000	N
Work/business	6.38	27	10.84	41	16.16	96
Social	5.79	116	6.98	57	7.86	133
Recreational/other	4.31	65	5.57	52	7.04	144
General	5.01	230	7.04	153	10.29	376

A large amount of international research exists concerning the value of time in public transport. A comparison with other research is important to assess the validity of the model. Recently, a large study is conducted by Significance et al. (2012) to obtain values of time for several travel modes within the Netherlands. The aim of that study was to establish values which can be used by the Dutch government in social cost-benefit analyses of infrastructure projects. Since this is the largest and most recent study within the context of the Netherlands, this research is considered to be best suited for a comparison with the model results. The study by Significance et al. (2012) estimated different VOT's with a distinction by trip motive or by income group, but not for a combination of income group and trip motive. To make the results comparable, the VOT's displayed in Table 20 are averaged per trip motive to obtain one VOT per trip motive. Table 21 shows the obtained VOT's per trip motive for both the reference study and the model estimation of this research. The comparison shows that the obtained VOT's in this study are in close range from the values of the reference study, which is a strong indication of a good validity of the model.

Table 21: Value of time for train (in euro per person per hour)

Model	Reference value (Significance et al., 2012)	Average value model estimation
Work/business	11.50 – 15.50	13.22
Social	7.00	6.91
Recreational/other	7.00	6.06
General	9.25	8.03

Significance et al. (2012) also provides separate VOT's per income group. The income groups used by Significance et al. (2012) have different thresholds and are expressed in net income per household, which makes the results difficult to compare. The comparison of VOT's per income group is shown in Table 22. The reference study obtained higher VOT's, which can be explained by the definition of the income group. The value of a gross income, corresponds with a lower value of net income.

Table 22: Value of time for train (in euro per person per hour)

Income group (net income per household in euro)	Reference value (Significance et al., 2012)	Income group (gross income per person in euro)	Average value model estimation
<1.875	9.50	<2000	5.01
1.875- 3.125	11.00	2000-3000	7.04
3.125- 4.325	13.80	3000-6000	10.29
> 4.325	14.25		

The VOT's based on trip motive, which are best suited for a comparison, are well within the range of the reference values. Therefore the obtained values of time in the SP experiment are considered valid.

5.2.4 Headway of connecting mode

The headway is modeled as a dummy parameter with a headway of 15 minutes fixed to zero. This means that the utility of a headway of 20 or 30 minutes is not the absolute utility of this headway, but the relative utility compared to a headway of 15 minutes. The relative utilities of the headways are shown in Figure 15 to Figure 18, based on the model estimations included in appendix E1-E5).

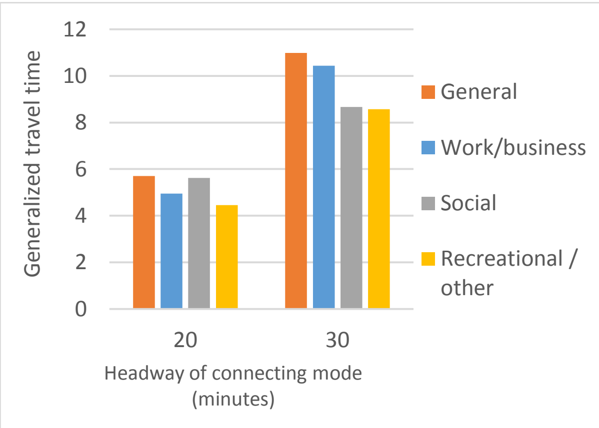


Figure 15: Utility of headway by trip motive

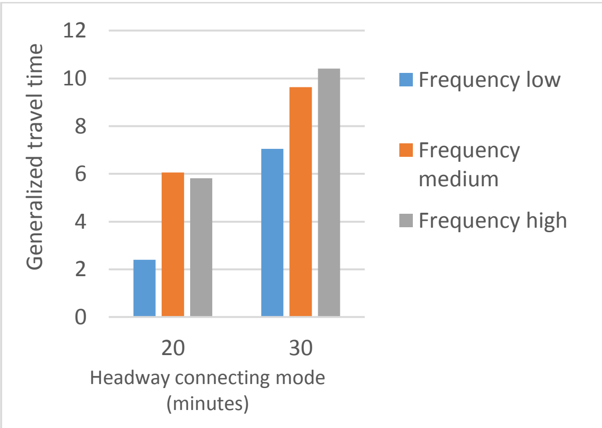


Figure 16: Utility of headway by travel frequency

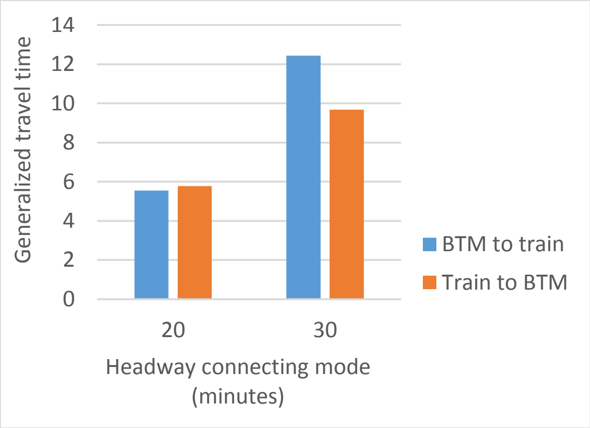


Figure 17: Utility of headway by access or egress transfer

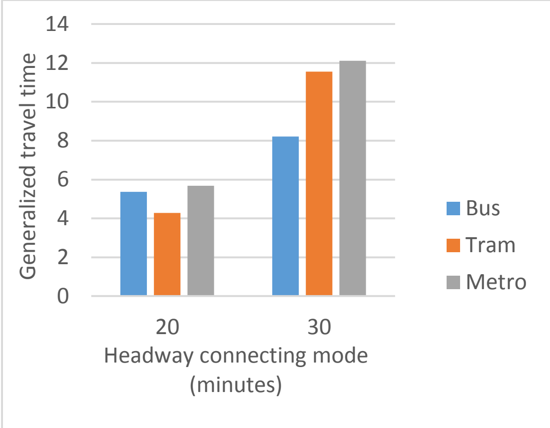


Figure 18: Utility of headway by mode

The headway of the connecting mode represents the extra waiting time when the connection is missed. In most cases, a headway of every 20 minutes adds 4 to 6 minutes generalized travel time to the total disutility of the trip, compared to a headway of every 15 minutes. This is notable, since this means that one extra minute possible extra waiting time is approximately equal to one in-train minute. The valuation of a headway of 30 minutes adds 7 to 12 minutes generalized travel time to the total disutility of the trip. This result is in line with research of Haarsman (2012) where a minute of possible extra waiting time was valued as 0.7 in-train time minutes (compared to 0.5-0.8 in this research).

The largest differences are observed by travel frequency and mode. Infrequent travelers award less disutility to larger headways, which is in accordance with other findings that these travelers are less time-conscious. When the model is specified by BTM mode, especially the disutility for a headway of every 30 minutes is high for the tram and metro. In reality, headways for tram and metro are often smaller, which can explain this high disutility.

A further distinction by mode is shown in Figure 19, where a distinction between access transfers and egress transfers is made as well. The figure shows that some differences in utility occur dependent on the combination of BTM mode and transfer type.

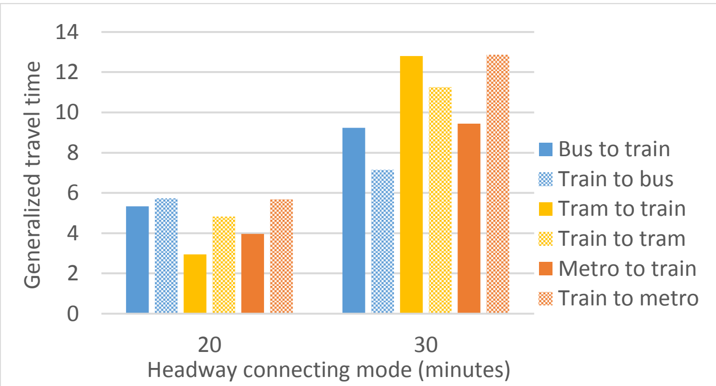


Figure 19: Utility of headway by mode and transfer type

5.2.5 In-train time

The valuation of in-train time is approached by a piecewise-linear function. A minute extra train time has a smaller effect for trips with an in-train time of more than 90 minutes, compared to a trip with an in-train time of less than 90 minutes. This effect is only significant for infrequent travelers. A minute extra in-train time above 90 minutes is valued as 0.7 minutes generalized travel time (appendix E5). The insignificant effects within the other groups might be caused by the low amount of trips with in-train times over 90 minutes within these groups.

Similar values are obtained in other studies. Haarsman (2012) found a value 0.75 minutes generalized travel time for a minute in-train time above 90 minutes. Arentze and Molin (2013) reported a decreasing effect of in-train time for longer trips as well. For train trips of more than 65 kilometers, an extra minute in-train time is valued is 0.81 minutes generalized travel time. The decreasing effect of in-train time is shown in Figure 20.

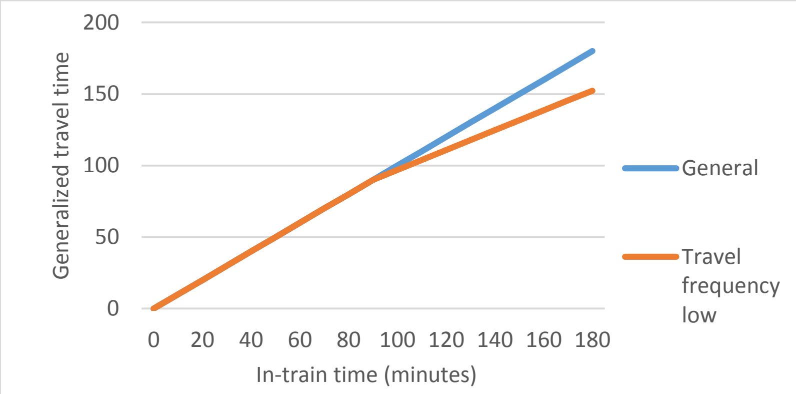


Figure 20: In-train time versus generalized travel time

5.2.6 Station type

Only small differences are found in the valuation of station types. For travelers with the trip motive recreational/other, a positive utility of 4 minutes generalized travel time is awarded when the transfer takes place at a very large station. This means that these travelers are willing to spend 4 minutes more travel time to have a transfer at such a station. For the other trip motives the difference between station types was insignificant.

The literature study identified several aspects of station facilities which influences the transfer disutility. For example shelter from weather, availability of escalators, seating and shops makes the station a more pleasant place to stay. These facilities are in general more available on larger stations. On the other hand, the walking time will increase and it can be harder to find the way on a large station, which is perceived negative.

5.2.7 Transfer time

The transfer times are modeled as dummy variables with a transfer time of 8 minutes fixed to 0. The parameters for transfer time are alternative specific. For a BTM-train transfer in the general model, all transfer times other than 8 minutes are perceived negative relative to a transfer time of 8 minutes. Figure 21 to Figure 24 show the relative disutility of transfer times other than 8 minutes.

A distinction by access or egress transfers (Figure 21 and appendix E4) shows that transfer times other than 8 minutes are less penalized for egress transfers than for access transfers. A distinction by trip motive (Figure 22 and appendix E2) shows large differences for short transfer times (3 or 5 minutes). These are perceived negative by travelers with trip motive social and recreational/other. For trip motive work/business, the values for 3 and 5 minutes are not significantly different from 8 minutes. These results are in accordance with literature, which states that goal-orientedness and time play an important role for this group. Travelers with trip motive social or recreational attach greater value to convenience and comfort, which is expressed by the higher disutility of small transfer times.

A similar pattern is present with a distinction by frequency (Figure 23 and appendix E5). Transfer times of 3, 5 or 8 minutes are valued approximately equal by travelers with a travel frequency of once per week or more (difference is insignificant), while travelers with a lower travel frequency attach a disutility to a transfer time of 3 or 5 minutes. Literature already showed that familiarity with the station is an important aspect influencing the transfer disutility. The familiarity of a station is highly correlated with the travel frequency, therefore it makes sense that high-frequent travelers prefer lower transfer times than infrequent travelers.

With a distinction by mode (Figure 24 and appendix E3), the parameter values for a transfer time of 3 or 5 minutes is insignificant for metro. This can be caused by the frequency of the metro, which is usually very high. The parameter value for a transfer time of 5 minutes by tram is insignificant as well. This means, that these transfer times are not valued differently than a transfer time of 8 minutes.

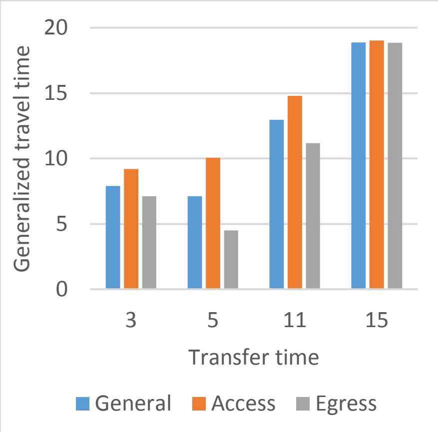


Figure 21: Relative valuation of transfer time with a distinction for access and egress transfer

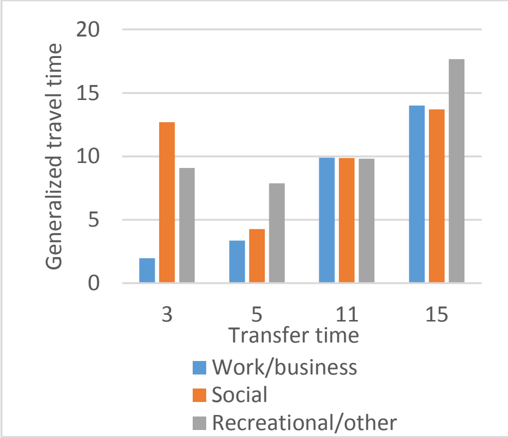


Figure 22: Relative valuation of transfer time with a distinction by trip motive

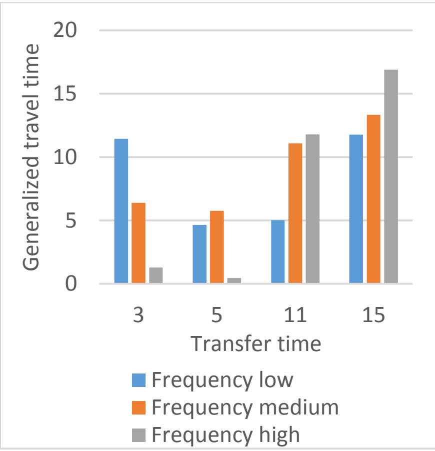


Figure 23: Relative valuation of transfer time with a distinction by travel frequency

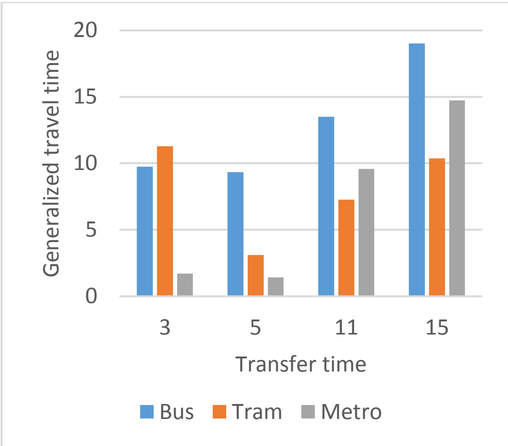


Figure 24: Relative valuation of transfer time with a distinction by mode

The figures above showed the distinctions for trip motive, trip stage, travel frequency and BTM mode. Further distinctions within these categories are made by trip stage (access/egress). These results are presented below.

For the distinction by trip motive in combination with a distinction by access/egress (Figure 25 and appendix E7/E11), again the valuation of a transfer time of 3 or 5 minutes for trip motive work/business is not significantly different from 8 minutes. Furthermore, the figure shows that the differences between an access and an egress transfer which were already visible in general, are present within the specific trip motives as well.

For the different BTM modes (Figure 26 and appendix E8/E12), especially the difference between access and egress is large for the bus, with transfer times of 3 or 5 minutes. The disutility of a transfer time of 3 or 5 minutes for an access transfer is around 13 minutes while, the disutility for an egress transfer is around 6 minutes. Train stations are often the start- and endpoints of a bus line. Due to delays which can occur in traffic, the unreliability of the arrival time of the bus at the station might be larger than the departure of a bus from the station. Therefore, travelers might prefer larger transfer times in their access trips by bus.

The distinction by travel frequency in combination with access/egress is shown in Figure 27 (appendix E9/E13). Again, the general differences between access and egress transfers are clearly visible. These differences are especially large for the low and medium-frequent travelers, where access transfers are perceived worse.

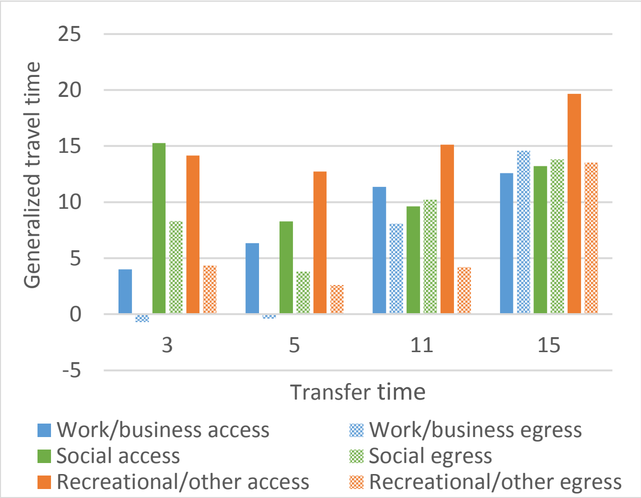


Figure 25: Relative valuation of transfer time with a distinction by trip stage and trip motive

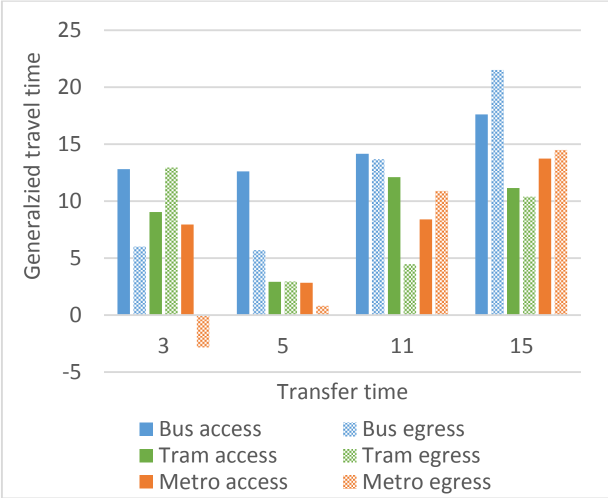


Figure 26: Relative valuation of transfer time with a distinction by trip stage and BTM mode

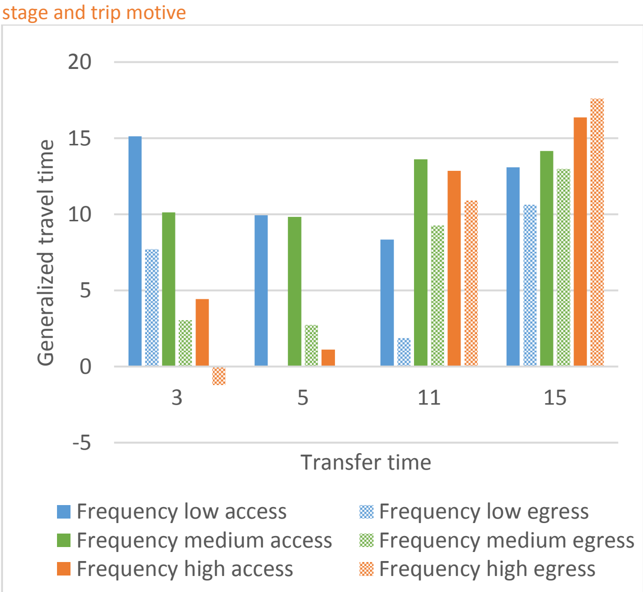


Figure 27: Relative valuation of transfer time with a distinction by trip stage and travel frequency

5.3 Additional analyses

Besides the model estimations based on the SP experiment, the data obtained in the survey contains other interesting information, which will be presented in this section. The preferred transfer time, directly derived from the respondent is discussed in the first section. The second section discusses travelers with the trip motive school/study. The station assessments are presented in the third section. The fourth section shows results of a model estimation on station level.

5.3.1 Preferred transfer time

Five levels of transfer time (3, 5, 8, 11, and 15 minutes) are included in the SP experiment. Transfer times lower or higher than 8 minutes are perceived negative according to the general model. The survey also included a question directly asking about the preferred transfer time in a BTM-train transfer at the station of the RP trip. The average value of preferred transfer time was 7.57 minutes, which is in accordance with the model estimation. Table 23 shows the average preferred transfer time as was indicated by the respondents. Different segmentations are made to find systematic differences. The most important differences are discussed below.

Table 23: Average preferred transfer times for different segmentations

Category	N	Average (minutes)	Standard deviation	Standard error
Total average	1064	7.57	3.75	0.11
Type of transfer				
BTM to train	515	8.26	3.87	0.17
Train to BTM	549	6.93	3.52	0.15
Tripmotive				
Work/business	361	6.30	3.46	0.18
School/study	83	6.45	3.03	0.33
Social	341	8.59	8.72	0.47
Recreational/other	279	8.81	3.63	0.22
Travel frequency				
Once a week or more	535	6.50	3.30	0.14
1-3 times a month	268	7.99	3.60	0.22
Less than once a month	261	9.36	4.01	0.25
Mode				
Bus	616	7.94	3.87	0.16
Tram	275	7.76	3.65	0.22
Metro	173	5.98	3.02	0.23
Specific station				
Amsterdam Centraal	155	7.83	3.29	0.26
Utrecht Centraal	99	9.00	4.95	0.50
Den Haag Centraal	78	8.10	3.65	0.41
Rotterdam Centraal	69	8.33	4.20	0.51
Eindhoven	44	8.80	4.70	0.71
Amsterdam Amstel	42	5.33	3.00	0.46
Stationtype				
Type 1	456	8.25	4.05	0.19
Type 2	324	7.78	3.58	0.20
Type 3	168	5.66	2.83	0.22

Significant higher transfer times are preferred for access transfers than for egress transfers. No significant differences are observed between trip motives work/business and school/study. However, travelers with trip motive social or recreational/other prefer a higher transfer time. These results are in accordance with literature which states that work/business travelers are more time-conscious.

Significant differences also occur between the three distinguished groups of travel frequencies. A lower travel frequency leads to a higher preferred transfer time. This is also in accordance with the expectations since the infrequent travelers are often less familiar with the station. Furthermore, a correlation exists between trip motive and travel frequency.

With a distinction by BTM mode, a significant difference is found in the preferred transfer time from or to a metro, compared to a bus or tram. Metro stops are often more integrated within the train station and sometimes even a cross-platform transfer between train and metro is possible. This could explain the lower preferred transfer time. Furthermore, the frequency of metro services is often very high, which makes a small transfer time more acceptable. In the occasion of a missed connection, the extra waiting time is still limited.

Another distinction is made on station level. The six stations with the highest amount of respondents are presented in Table 23. The preferred transfer time at Amsterdam Amstel is several minutes lower than the other stations. This could be explained by the fact that out of 42 respondents at Amsterdam Amstel, 22 respondents transferred to or from the metro. Utrecht Centraal has the highest preferred transfer time, which can be explained by the relatively large walking distances at this station. No large differences occurred between the other stations. With distinctions per station type, no significant differences are observed between station type 1 and type 2, while the preferred transfer time of station type 3 is significantly lower. Stations of type 3 are often stations with a transfer function to tram or metro, therefore a correlation with these modes exists.

Another possible direction to find an explanation for the large variation in preferred transfer times is the assessment of the specific station by the respondent. It is expected that the preferred transfer time is correlated with the assessment of the transfer speed of a station. However, no correlations occurred between the preferred transfer time and the assessment of transfer speed at the station.

5.3.2 Trip motive school/study

Results for the trip motive school/study are not included in section 5.2. The amount of respondents within this trip motive was too low to estimate a reliable model. However, to give an idea about this group, this section compares the trip motive school/study with the other trip motives to determine if the trip motive school/study is comparable with one of the other trip motives.

80% of the respondents with trip motive school/study have a travel frequency of once per week or more (which is comparable to 85% for trip motive work/business). Furthermore, the average length of the RP train trip was 39 minutes (compared to 28 minutes for work/business and 93 minutes for social/recreational). The previous section already showed that the preferred transfer time for travelers with the trip motive school/study is comparable with travelers with the trip motive work/business. The obtained cost parameters suggest that the cost sensitivity for trip motive school/study is higher than for the other trip motives. To conclude, the trip motive school/study has some similarities with the trip motives work/business concerning the travel characteristics, however, since differences occur on the valuation of costs, travelers with these trip motives cannot be treated equally as work/business travelers.

5.3.3 Station assessment

Respondents indicated in the survey at which train station they transferred from or to BTM. Six aspects of this station are assessed on a scale from 1 to 10 (where 1 is the lowest score and 10 the highest). The aspects to evaluate with the average scores and standard deviations are shown in Table 24.

Table 24: Assessment of transfer station for different aspects

	All respondents		Work/ business		School/ Study		Social		Recreational / other	
Assessed aspect	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
General assessment	6.92	1.49	6.71	1.53	6.94	1.40	7.08	1.47	6.99	1.44
Place to stay	6.05	1.91	5.76	1.89	5.80	2.01	6.25	1.94	6.27	1.83
Safety	6.91	1.52	6.82	1.62	6.84	1.47	7.02	1.47	6.90	1.43
Overview	6.73	1.70	6.46	1.77	6.99	1.76	6.94	1.63	6.76	1.65
Availability of shops	6.86	2.05	6.86	2.04	6.85	2.22	6.81	2.14	6.94	1.88
Transfer speed	7.14	1.61	6.94	1.74	7.16	2.03	7.34	1.49	7.17	1.41

In general, respondents with trip motive work/business and school/study assess the different aspects lower than respondents with trip motive social and recreational/other. The assessment of the station as a comfortable place to stay scores low for all trip motives, in comparison with the other assessments.

For the six stations with the highest amount of respondents, the assessments per station are presented in Table 25. Large differences between stations occur, especially for Rotterdam Centraal. This station is recently rebuilt, which is perceived very positive by travelers, according to these results. Since these large differences occur for Rotterdam Centraal station, a separate model is estimated only including respondents using this station. This model will be discussed in the next section.

Table 25: Assessments per station

Station	Amsterdam Centraal		Utrecht Centraal		Den Haag Centraal		Rotterdam Centraal		Eindhoven		Amsterdam Amstel	
Assessed aspect	Mean	St. dev.	Mean	St. dev.	Mean	St. dev	Mean	St. dev.	Mean	St. dev	Mean	Std. dev.
General assessment	6.96	1.26	6.52	1.64	6.75	1.42	8.64	1.07	6.64	1.37	7.15	0.96
Place to stay	6.06	1.80	5.97	1.87	5.88	1.81	8.29	1.31	5.81	1.84	6.33	1.58
Safety	6.92	1.41	6.83	1.32	6.73	1.56	8.08	1.28	7.02	1.27	6.90	1.21
Overview	6.52	1.62	5.55	1.90	5.91	1.67	8.24	1.29	6.68	1.79	7.12	1.17
Availability of shops	7.69	1.55	7.72	1.45	6.70	1.69	8.69	1.16	6.93	1.49	7.45	1.22
Transfer speed	7.17	1.43	6.04	1.92	6.81	1.51	8.13	1.20	6.84	1.94	7.80	1.29

5.3.4 Comparison of Rotterdam Centraal and Den Haag Centraal

The previous section showed that the mean score of the assessed station aspects is remarkably higher for station Rotterdam Centraal. A separate model is estimated only including respondents who used station Rotterdam Centraal in their RP trip. To make a comparison with another station, a separate model for Den Haag Centraal is also estimated. Den Haag Centraal is chosen as comparison since renovations currently take place which might have an effect. Furthermore, this station is interesting for NS since they partly own bus and tram service provider (HTM). A few characteristics of these stations are summarized in Table 26 below.

Table 26: Station characteristics (based on internal NS documentation, year 2012)

	Rotterdam Centraal	Den Haag Centraal
Station type	1	1
Daily amount of travelers boarding and alighting	98.000	74.000
Access by BTM	50%	62%
Egress by BTM	38%	33%
Assessment of connection with BTM	7.1	7.3
BTM seats	21000	16000

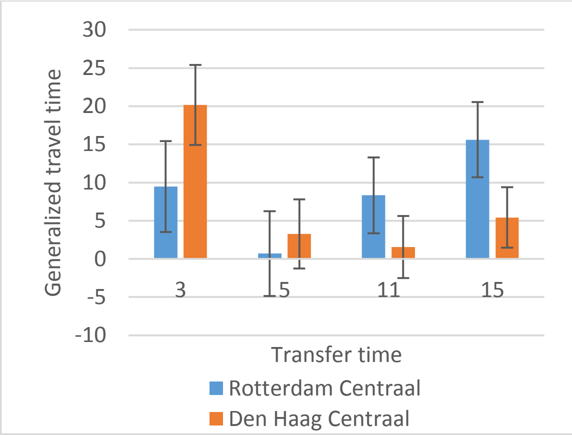


Figure 28: Relative valuation of transfer time on station level

For both stations, a general model and two models with a distinction by access or egress transfers are estimated (included in appendix E6, E10 and E14). These models should be interpreted with caution because the selection is based on the station which is last used by the respondent. However, no station names are mentioned within the SP experiment. Therefore, the respondent does not necessarily have this specific station in mind as reference. Figure 28 shows the relative valuation of transfer times, including the standard error. Large standard errors occur due to the low amount of respondents. Because of these large standard errors, the differences between the stations are not significant and no conclusions can be drawn on station level.

6. Application of results

The previous chapter presented the results from the different model estimations. Differences between trip motives, travel frequencies and modes are identified. This chapter demonstrates how the results can be applied. The first section provides some examples on the calculation of choice probabilities. Values for the total transfer disutility are derived in the second section. The third section provides practical recommendations for NS on the implementation of the results in their route assignment model. Furthermore, some recommendations are provided to decrease the transfer disutility.

6.1 Choice probabilities

The utility functions resulting from the model estimations can be used to estimate the probability of a traveler to choose one alternative over another alternative, as is explained in section 2.3.1. This can give more insights into the importance of the different attributes. This section demonstrates the probabilities for different choice situations. A base alternative is used in all comparisons which consists of the following attribute levels:

- BTM trip of 15 minutes
- Transfer time of 8 minutes
- Train time of 36 minutes
- Headway of connecting mode of 15 minutes
- Transfer station: medium/large.

The train time is set on 36 minutes since this is the average duration of a train trip according to internal NS data. No data on the average BTM trip time is known, therefore the average BTM trip time from the sample of this research is used. For the dummy variables (transfer time, headway and transfer station), the attribute values are chosen which are fixed to 0 in the models. This way, the largest variations can be demonstrated. Costs are not included to keep the examples simple. Attribute values and the type of respondents are varied in a second alternative to demonstrate the effect on the choice probabilities.

6.1.1 Effects of transfer time on choice probabilities

The parameters from the general model (Appendix E1) are used to estimate the utility function of a trip consisting of a bus access trip and a train main trip. The utilities of the two alternatives are shown in Table 27.

Table 27: Example of utility of two alternatives

	Alternative 1			Alternative 2		
Characteristic	Value	Utility per unit	Total utility	Value	Utility per unit	Total utility
Access time by bus (minutes)	15	-0.0629	-0.944	15	-0.0629	-0.944
Headway connecting mode (minutes)	15	0	0	15	0	0
In-train time (minutes)	36	-0.054	-1.944	36	-0.054	-1.944
Transfer time (minutes)	8	0	0	15	0	-1.020
Total			-2.888			-3.908

By changing the transfer time from 8 to 15 minutes (while keeping all the other attributes constant), the utility is changed by -1.020 to a total of -3.908. The GTT changed from 53.5 minutes to 72.4 minutes. The probability of choosing alternative 2 over alternative 1 can be calculated as is explained in section 2.3.1:

$$P_{alternative2} = \frac{e^{V_{alternative2}}}{e^{V_{alternative2}}+e^{V_{alternative1}}} = \frac{e^{-3.908}}{e^{-3.908}+e^{-2.888}} = 0.265$$

The probability of choosing alternative 2 is 26.5%, showing that the transfer time is considered as very important by travelers. Since the difference in error components was insignificant between the two BTM-train alternatives, it is not used in this probability calculation.

In the same way, the probability is calculated for a trip with a transfer time of 3 minutes instead of 8 minutes. Extra parameters are included in the model for a transfer time of three minutes when someone is aged older than 60 and when someone is a high frequent traveler. The choice probabilities of choosing the alternative with 3 minutes transfer time over the alternative with 8 minutes transfer time are shown in Table 28 for different types of travelers. A distinction is made for a regular traveler, a frequent traveler and a traveler aged over 60. The choice probabilities are clearly different, demonstrating the effect of personal characteristics on the valuation of transfer time.

Table 28: Choice probability of choosing alternative with 3 minutes transfer time

	Probability of choosing alternative with transfer time of 3 minutes over alternative with transfer time of 8 minutes
Regular traveler	39.5%
Frequent traveler	49.6%
Traveler aged over 60	30.0%

6.1.2 Effect of headway and station size on choice probabilities

In the same way as in the previous section, the choice probability is calculated when the headway of the connecting mode is decreased from every 15 minutes to every 30 minutes. The probability of choosing the alternative with the headway of the connecting mode of every 30 minutes over the probability of the alternative with the headway of every 15 minutes is 35.6%, with the model specification of the general model (Appendix E1). The choice probabilities of choosing the alternative with a headway of every 30 minutes, distinguished by BTM mode, are shown in Table 29. The table shows that the headway is least effecting the choice probabilities for the bus, and that the greatest effects occur for a transfer to or from metro. Because the frequency of the metro is in reality often higher, travelers might be less willing to accept a headway of 30 minutes for a metro than for a bus.

Table 29: Choice probabilities of choosing the alternative with headway of 30 minutes

	Probability of choosing alternative with headway of 30 minutes over alternative with headway of 15 minutes
Bus	39.3%
Tram	33.5%
Metro	28.2%

The station size of the transfer station was found only to be significant for recreational travelers. With the model estimation for recreational travelers (Appendix E2), the probability of choosing the alternative with a very large transfer station instead of a medium or large transfer station is 53.8%, which is a relatively small effect, compared to the effect of transfer times and headways.

6.1.3 Difference between BTM-train and train-train alternative.

The previous examples gave the choice probabilities for two BTM-train alternatives with one attribute varying. This section compares a BTM-train alternative with a train-train alternative. Since the error component is significant for the train-train alternative in the models, the probabilities must be calculated through simulation, as is explained in section 2.3.4. 10,000 draws are taken from the distribution to calculate the average probability. The attributes of both alternatives with the utilities according to the model estimation of Appendix E1 are shown in Table 30.

Table 30: Utility of BTM-train and train-train alternative

Characteristic	BTM-train alternative			Train-train alternative		
	Value	Utility per unit	Total utility	Value	Utility per unit	Total utility
Alternative specific constant			-0.256			0
Access time (minutes)	15	-0.0629	-0.9435	15	-0.054	-0.81
Headway connecting mode (minutes)	15		0	15		0
In-train time main trip (minutes)	36	-0.054	-1.944	36	-0.054	-1.944
Transfer time (minutes)	8		0	8		0
Total			-3.1435			-2.754

When all the attribute values are equal, the probability that a traveler chooses the BTM-train alternative is 41.6%. This shows that there is a preference for the train-train alternative.

6.2 Transfer disutility

This section derives the total transfer disutility for transfers between BTM and train, expressed in generalized travel time. This transfer disutility cannot be derived directly from the model results since it is not possible to compare a trip with a transfer to a trip without a transfer. In the model estimations, the parameter values for a transfer time of 8 minutes and a headway of the connecting mode of every 15 minutes are fixed to zero. The parameter values for a transfer time of 3, 5, 11 and 15 minutes therefore give the relative disutility of this transfer time, compared to a transfer time of 8 minutes. These values are given in Table 31 (based on the model estimation of the access and egress models by mode, appendix E8 and E12).

Table 31: Relative disutility for transfer times other than 8 minutes for BTM-train transfers

	Relative disutility (generalized travel time)					
Transfer time (minutes)	Bus to train	Train to bus	Tram to train	Train to tram	Metro to train	Train to metro
3	13	6	9	13	8	0
5	13	6	0	3	0	0
8	0	0	0	0	0	0
11	14	14	12	5	8	11
15	18	22	11	10	14	15

The alternative-specific constants in the models with a distinction by trip stage and mode are insignificant. This means that no difference is found for a BTM-train or a train-train transfer with a transfer time of 8 minutes. Therefore, the total BTM-train transfer disutility can be estimated by adding the corresponding value of Table 31 to the transfer disutility of a train-train transfer with a transfer time of 8 minutes and a headway of every 15 minutes. Extensive research within NS (Haarsman, 2012; de Keizer et al., 2012; de Keizer & Hofker, 2013; de Keizer, Kouwenhoven, & Hofker, 2014) established penalties for train-train transfers. A train-train transfer with a transfer time of 8 minutes and a headway of every 15 minutes receives a transfer penalty of 29 minutes. The resulting total transfer disutilities for BTM-train transfers are shown in Figure 29.

The transfer disutilities shown in Figure 29 are applicable when the headway of the connecting mode is every 15 minutes. For larger headways (every 20 minutes or every 30 minutes) the transfer disutility is higher. The additional disutility per mode and transfer type is shown in Table 32.

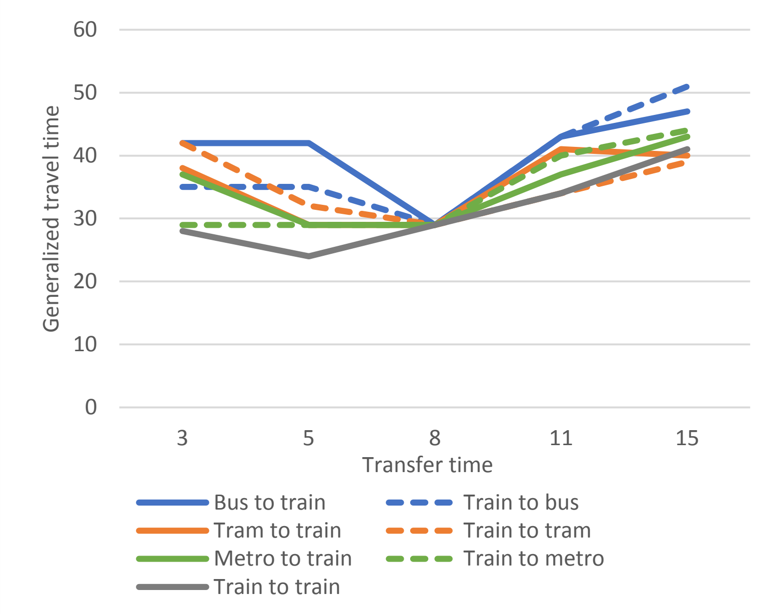


Figure 29: Overview of transfer disutility by mode

Table 32: Extra disutility in transfers with larger headways

	Bus to train	Train to bus	Tram to train	Train to tram	Metro to train	Train to metro
Every 20 minutes	5	6	0	5	4	6
Every 30 minutes	9	7	13	11	9	13

In short, the transfer disutility consists of a basic disutility for a transfer time of 8 minutes and a headway of every 15 minutes for the connecting mode. For other transfer times, the corresponding value from Table 31 should be added. For other headways, the corresponding value of Table 32 should be added.

6.3 Practical application by NS

This research resulted in a set of different models with a vast amount of parameters. These extensive distinctions provide interesting insights into the differences between several trip and personal characteristics. The results can be used by NS to extend their trip assignment model (which is currently only suited for train trips) and make it suitable for BTM as well. The model used by NS is using less parameters than the estimated models of this research and therefore the results are not directly applicable. This section provides recommendations on parameters to use by NS in their model which are directly applicable.

6.3.1 Description of route assignment model used by NS

NS uses the route assignment model VISUM to assign travelers to different routes. Currently, the transfer disutility between trains is represented by a single value. Based on de Keizer et al. (2014), the transfer disutility between trains will be adapted and consist of a few elements:

- A basic disutility of 23 minutes GTT (with a transfer time of 2 minutes and a headway of every 15 minutes)
- An extra penalty or bonus depending on the transfer time
- An extra penalty or bonus depending on the headway of the connecting train
- An extra penalty of 7 minutes GTT if the transfer is cross-station instead of cross-platform

More information on the calculation of the transfer disutility between trains by NS is provided by de Keizer et al. (2014).

6.3.2 Recommendations on parameters for BTM modelling in VISUM

To make the implementation of BTM in VISUM possible, values for the transfer disutility and a value for in-vehicle time BTM should be established. Differences are observed in this research between different trip motives, travel frequencies, modes and access/egress. Since trip motives and travel frequencies are currently not included in VISUM, these will also not be included for BTM.

Similar to the train-train transfer disutility, a basic disutility can be used with an additional penalty depending on the transfer times. The basic transfer disutility is 29 minutes GTT for a transfer time of 8 minutes. Table 31 in section 6.2 shows the additional penalties for different transfer times and modes and types of transfer (access/egress). There is a lot of variation in the values which makes it difficult to use one general value. Therefore it is recommended to keep these distinctions.

Disutility is added if the headway of the connecting mode is larger than 15 minutes both in the models from this research and in the model from de Keizer et al. (2014). The values in both models are not significantly different from each other, therefore it is recommended to use the values which are already used for train-train transfers.

Table 33 summarizes the recommended elements which should be considered to establish the transfer disutility for a BTM-train transfer in VISUM. The current estimation of train-train transfer disutility is shown as well. The transfer disutility for BTM-train transfers can be calculated in the same way as the disutility of a train-train transfer, only a few values need to be changed.

Table 33: Recommended transfer disutility BTM-train in VISUM compared to transfer disutility train-train

Resistance factor	Train-train (de Keizer et al., 2014)	BTM-train
Basic transfer disutility	23 minutes GTT (including transfer time 2 minutes, headway connecting mode 15 minutes)	29 minutes GTT (including transfer time 8 minutes, headway connecting mode 15 minutes)
Cross station transfer	+ 7 minutes	-
Transfer time	According to table de Keizer et al. (2014)	According to Table 31
Headway of connecting mode	According to table de Keizer et al. (2014)	According to table de Keizer et al. (2014)

Different values for access/egress time by BTM are obtained in the model estimations as well. Differences are found between the valuation of access time and egress time. However, since there is no clear explanation for this difference and to keep the implementation in VISUM less complex, it is recommended only to make a distinction by mode. The average access/egress time by bus is found to be valued different from the in-vehicle time by train. The average value for one minute access/egress time by bus is 1.28 minutes GTT (according to the general model, appendix E1). The values obtained for in-vehicle time in tram and metro are not significantly different from the value obtained for in-vehicle time in the train. Therefore it is recommended to consider a minute of in-vehicle time by tram/metro equal to a minute in-vehicle time by train. Table 34 shows the recommended values for in-vehicle time in BTM, relative to in-vehicle time in train.

Table 34: Recommended values in-vehicle time BTM

Mode	Valuation of 1 minute in-vehicle time (GTT)
Bus	1.28
Tram	1
Metro	1

6.3.3 Simplified transfer disutility BTM-train

The previous section described a procedure to determine the transfer disutility for a BTM-train transfer, dependent on mode, transfer time, and headway. For NS, it can sometimes also be convenient to have an average value for the transfer disutility to obtain quick insights in the general effect of a BTM-train transfer. This value will be based on an average transfer.

Internal research by NS and HTM showed that the average transfer time between BTM and train is approximately 10 minutes. This is based on OV-chipcard data from travelers in the Hague. A transfer time of 11 minutes is used because this is the closest dummy parameter in the model. The average headway of a train is 17 minutes (de Keizer & Hofker, 2013). The average headway of BTM can be smaller in some occasions, but these small headways are not included in the research. Therefore, a headway of 15 minutes will be used as average. With these characteristics (transfer time of 11 minutes and a headway of every 15 minutes), the transfer disutility for an average BTM-train transfer is 42 minutes GTT. The transfer disutility for an average train-train transfer is 34 minutes (de Keizer & Hofker, 2013). A distinction by mode can be mode as well. No significant differences between tram and metro occur, therefore this distinction is not made. The resulting values are presented in Table 35.

Table 35: Average transfer disutility by mode

Mode	Transfer disutility of an average transfer (GTT)
All BTM	42
Bus	43
Tram/metro	37

The value for all BTM is close to the value for bus. This is because the largest part of the respondents used the bus as access/egress mode (as is reported in section 4.3.2).

6.3.4 Policy implications

The total experienced transfer disutility for transfers between BTM and train can largely be influenced by adjusting the transfer times and the headways of the connecting modes. In general, the optimal transfer time is around 8 minutes. However, chapter 5 showed that differences occur between different trip motives and travel frequencies. Therefore, if the majority of travelers on a certain transfer have the same trip motive or travel frequency, the transfer times can be adjusted to these types of travelers. For example, during the morning peak hours, the majority of the respondents will be frequent work/business travelers, who prefer a transfer time of 6 minutes instead of the average value of 8 minutes. Furthermore, section 5.3 showed that the preferred transfer time can largely differ per station. In general, larger transfer times are preferred for stations with high walking times. This means that it could be useful to adjust the transfer time to the local situation.

To achieve optimal transfer times, coordination should take place between train and the BTM services. This can be a challenge since train and BTM services are operated by different companies in most occasions. Furthermore, optimizing the transfer time for one connection can lead to a less optimal transfer time for another connection.

7. Conclusions, recommendations and discussion

This chapter reports on the conclusions of this research. Furthermore, the results are discussed and directions for further research are provided

7.1 Conclusions and recommendations

The main objective of this research was formulated as follows:

"To determine the transfer disutility of a transfer between BTM and train and quantify the influence of travel time, transfer time, headway, costs and station facilities on such a transfer. Furthermore, differentiate these attributes for personal and trip characteristics."

To achieve these objectives, several research questions are formulated in section 1.2. The research questions are answered below one by one.

1. *What are important attributes influencing the disutility of a transfer between train and BTM according to literature?*

The main elements contributing to the disutility of a trip are time, costs and effort. In accordance with the random utility theory, it is assumed that a traveler choses the option which maximizes his total utility. For a multimodal transfer, effort is a very important element. The total effort needed for a transfer consists of several components, like walking time, waiting time, reliability, safety, travel information, station facilities, ticket integration, availability of staff, the type of transfer and the seat availability.

2. *How do personal- and trip characteristics influence the perceived transfer disutility according to literature?*

According to literature, there is a large taste heterogeneity concerning transfer disutility. The transfer disutility is perceived lower by commuters than by recreational travelers. Furthermore, if someone is more familiar with a station or is a frequent public transport user, the transfer disutility is also perceived lower. Someone traveling with large luggage or children experiences a larger disutility. Age and gender effects are found in literature as well with a higher perceived transfer disutility for females and people older than 50.

Trip characteristics also influence the transfer disutility. Some evidence is present in literature that the transfer disutility varies with the trip length, however the effect is not clear. The time of day can have an effect since this affects the perceived safety on a station, especially late at night. The transfer disutility is also dependent on the mode, with a greater disutility for transfers between train and other modes than train to train.

3. *What is the trade-off between in-vehicle BTM time, transfer time, in-vehicle train time, costs, headway and station facilities in combined BTM-train trips?*

The estimated models express the utility awarded to in-vehicle BTM time, transfer time, in-vehicle train time, costs, headway and station facilities. These utilities are all converted to generalized travel time (with a minute in-train time as reference value) to make the values easier to compare. The full overview of the trade-offs between the different attributes can be obtained from the different model estimations in appendix E.

A minute in-vehicle BTM time is found to be significantly different from a minute in-vehicle time by train for egress trips by bus. A minute egress time by bus is valued as 1.4 minutes GTT. All the other access/egress times are not found to be significantly different from one minute GTT.

The valuation of transfer time is not a linear function but depends on the specific transfer time. In general, a transfer time of 8 minutes is perceived with the highest utility. Lower and higher transfer times are perceived worse, up to 22 minutes of generalized transfer time. A similar effect is found in other research concerning a train-train transfer, where the ideal transfer time is found to be 5 minutes. A difference in the valuation of transfer time is found between bus, tram and metro. The largest effect of transfer time on the total transfer disutility occurs on transfers between bus and train.

The trade-off between time and costs is highly dependent on trip motive, income and whether or not the traveler pays for the trip himself. This trade-off is expressed in value of time (VOT) in euro per hour. The lowest VOT is found for travelers with the trip motive recreational/other, with a VOT varying between €4.31/hour and €7.04/hour, dependent on the income. The highest VOT is found for travelers with the trip motive work/business with a VOT varying between €6.38/hour and €16.16/hour, dependent on income. These values are in line with the most important VOT study in the Netherlands.

The headway of the connecting mode is important when a traveler misses his connection. Travelers took this headway into consideration when they choose a travel alternative. A headway of every 20 minutes instead of every 15 minutes led to an increase of generalized travel time between 2 and 6 minutes. A headway of every 30 minutes, relative to a headway of every 15 minutes leads to an increase of generalized travel time between 7 and 13 minutes.

Only small effects are found on station facilities. The difference between a medium/large station and a very large station was only significant for travelers with the trip motive recreational/other. These travelers perceived a very large station positive with a value of 4 minutes generalized travel time.

4. *How do personal characteristics and trip characteristics influence the importance of the different travel attributes?*

Several personal characteristics and trip characteristics are found to be influencing the sensitivity to the travel attributes. Travelers with trip motive work/business award less disutility to access/egress time by BTM than travelers with other trip motives. Furthermore, these travelers are more time-conscious and therefore perceive a transfer time of 3 or 5 minutes far better than travelers with the trip motive social or recreational/other. A relation is found in the models between the age of the traveler and the valuation of a transfer time of 3 minutes. Travelers of 60 years or older award far more disutility to such a small transfer time.

A correlation occurs between work/business travelers and high-frequent travelers. Therefore, similar results are found for high-frequent travelers. Low-frequent travelers appear to be less time-conscious since the headway of the connecting mode is less important and higher transfer times perceive less disutility as well. Furthermore, the disutility of in-train time is decreasing for longer trips (more than 90 minutes) for this group.

Access transfers (from BTM to train) are perceived more negative than egress transfers (from train to BTM). This could be explained by a higher unreliability of the arrival time of a BTM mode, compared to a bus.

5. *What is the transfer disutility of a BTM-train transfer, relative to the transfer disutility of a train-train transfer?*

For a transfer time of 8 minutes and a headway of every 15 minutes for the connecting mode, the transfer disutility of a BTM-train transfer is not found to be significantly different from the transfer disutility of a train-train transfer. The train-train transfer disutility for these attribute values is estimated in earlier research to be 29 minutes GTT. For other transfer times, a difference between BTM-train and train-train occurs. The transfer disutility for transfer times other than 8 minutes is dependent on the mode and the type of transfer (access or egress). An average transfer between bus and train (transfer time of 11 minutes and headway of 15 minutes) has a transfer disutility of 43 minutes GTT. An average transfer between tram/metro and train has a transfer disutility of 37 minutes. Other research showed that the transfer disutility for an average train-train transfer is 34 minutes.

6. *To what amount can the transfer disutility be decreased by changing the transfer characteristics?*

The transfer disutility is highly dependent on the transfer time and the headway of the connecting mode. Changing the transfer time from 15 minutes to 8 minutes can decrease the total transfer disutility by 10 to 22 minutes generalized travel time, dependent on the mode. An increase of headway from every 30 minutes to every 15 minutes decreases the total transfer disutility between 7 and 13 minutes generalized travel time. Smaller headways than every 15 minutes are not included in this research, but are expected to decrease the total transfer disutility. Differences in the preferred transfer times between trip motives and travel frequencies occur as well. When the majority of travelers on a specific transfer all have the same trip motive or travel frequency, the transfer time could be adjusted to the specific situation, for example shorter transfer times for high-frequent work/business travelers.

7.2 Discussion

This section discusses the validity of the results and the possible weaknesses in the methodology. Four major points of discussion are described: the representativeness of the sample, the exclusion of attributes, the choice of the attribute levels and the validity of SP data.

7.2.1 Representativeness of sample

The sample is not fully representative for the NS population. Certain trip motives are under- or overrepresented. Especially the trip motive school/study was heavily underrepresented. In the model estimations, a weighting is applied to correct for this unrepresentativeness.

Since respondents had to indicate a recent train trip where BTM was used as an access mode or egress mode, respondents were recruited from the NS panel if they indicated in an earlier survey that they often use BTM as an access mode or egress mode for a train trip. This form of selection might have caused a positive bias towards the valuation of a BTM trip. However, respondents were asked about their frequency of BTM use as access or egress mode and respondents who did not often use BTM were well represented as well. Therefore it is expected, that this possible bias is limited.

7.2.2 Excluded attributes

To reduce the complexity of the SP experiment, not all attributes identified in literature to be influencing the transfer disutility are included in the SP experiment. Reliability is often mentioned in literature as an important aspect. In the current experiment, no indication of reliability is given, since this indication is not present in reality either. It is expected that the reliability is affecting the valuation of headway and transfer time. Respondents often mentioned to prefer a higher transfer time to compensate for small delays. In case of a higher reliability, the need to compensate for these delays will be smaller.

Some more aspects which are identified as important in literature are not included in the SP experiment to reduce the complexity. Therefore, it is unknown how attributes like travel information, availability of staff, time of day, familiarity with the station or seat availability contribute to the transfer disutility.

7.2.3 Attribute values

The presented attribute values in the SP experiment for access/egress time, in-train time and costs are a percentage of the values of a recent trip as reported by the respondent. This way, the respondents received choice situations close to their actual experience. However, when a small value for time or costs was reported, the absolute difference in attribute values in the choice experiment was also small. These small differences in attribute values occurred especially within the access / egress trip time. Therefore, it was more difficult to estimate the parameters for access / egress time in the model.

Furthermore, if a respondent reported high values, for example a high in-train time, the differences in attribute values for in-train time are large as well. This could cause the respondent to solely base his choice on this attribute. The reported trip times for the train trip were on average higher than the scheduled trip times. However, since the survey asked for the trip time on a specific trip, a delay could have occurred on this trip, which is included in the reported trip time.

The smallest headway of the connecting mode in the choice situations was every 15 minutes. The inclusion of smaller headways was not possible because this would lead to contextual constraints in combination with the transfer time. However, in reality, smaller headways can occur. It is expected that smaller headways will decrease the total transfer disutility, but it is not known to what amount this effect is present.

7.2.4 Validity of stated preference data

The choices in the SP experiment are presented in a way that they can be evaluated rationally. In reality, the choice process might be less rational. For example habits can play an important role as well. Furthermore, the simplifications made in the choice experiment could influence the choices as well. The BTM station and the train station were always at the same location and departed at the same time. In reality, when respondents have two travel options, they might just choose the first available possibility.

Since a fractional factorial design is used in the SP experiment, only main effects could be estimated. It was assumed that interaction effects between two or more attributes are negligible. In reality however, such interactions might occur. It is likely that the disutility of a short transfer time decreases as the headway of the connecting mode is increased. Another interaction could occur between the transfer time and the station size. For short transfer times, small stations might be preferred, since the walking times are in general shorter on these stations. For longer transfer times, larger stations might be preferred since these stations offer more possibilities to spend the waiting time.

7.3 Directions for further research

A separate analysis on the preferred transfer time showed that there are large differences in transfer times, based on several characteristics. Since the transfer time has a large influence on the total transfer disutility, further research into the explaining factors of preferred transfer times is recommended. This way, the transfer times can be optimized for specific situations.

The model based on trip motive school/study consists of a low amount of respondents, while 31% of the train trips is made with this trip motive. It is recommended for future research to put extra effort in the recruitment of respondents with this trip motive. The inclusion of all types of trip motives is important since this study shows substantial taste heterogeneity between different trip motives.

The models in this study are solely based on SP data. However, a joint RP-SP model might be more accurate. This might be hard to realize since an equal choice between a BTM-train alternative and a train-train alternative is not always present. This study collected the attribute values of a current BTM-train trip by the respondent. In a future similar research it would be useful to collect the attribute values of alternative modes as well.

A limited amount of attributes is included in the SP experiment. The effects of other attributes, like reliability, safety, travel information or familiarity with the transfer station can give additional insights into the perceived transfer disutility. Furthermore, the possible interactions between different attributes needs additional research to establish this relationship.

Currently, no distinction between bus, tram and metro is made in NS data. It is valuable to start making this distinction and obtain more insights into the use of each separate mode, since this study shows that these modes are not perceived homogenously.

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Appendix A: Survey

This appendix presents the survey questions. Table 36 below gives a summary of the topics for each question. The questions are formulated in Dutch.

Table 36: Overview of survey questions

Question	Subject	Obtained information
1	Travel frequency train	Travel characteristics
2	General trip motive	Travel characteristics
3	Frequency BTM access trip	Travel characteristics
4	Frequency BTM egress trip	Travel characteristics
5	Origin train station	Input for further RP questions
5	Destination train station	Input for further RP questions
6	Access mode	Input for SP experiment
7	Egress mode	Input for SP experiment
8	Trip motive specific trip	Input for SP experiment
9	In-train travel time	Input for SP experiment
10	Type of train ticket	Costs sensitivity
11	Who pays for trip	Costs sensitivity
12	Costs train trip	Input for SP experiment
13	Access/egress trip time	Input for SP experiment
14	Costs access/egress trip	Input for SP experiment
15	Available access/egress modes	Travel characteristics
	Access SP experiment	Model estimation data
	Egress SP experiment	Model estimation data
16	Remarks SP experiment	Survey quality
17	Transfer time specific trip	Information RP trip
18	Preferred transfer time specific trip	Preference
19	Headway of connection	Information RP trip
20	Assessment of elements transfer station	Assessment
21	Gender	Socioeconomic characteristics
22	Age	Socioeconomic characteristics
23	Working situation	Socioeconomic characteristics
24	Income	Socioeconomic characteristics
25	Education	Socioeconomic characteristics
26	Postal code	Socioeconomic characteristics
27	Remarks about BTM-train transfer	Elements not captured in the survey
28	General remarks	Survey quality

Respondents answered questions about an access trip or an egress trip (refer to section 3.2.1 for more information on the types of choice situations). Dependent on the indicated trip, respondents are assigned to one of the two groups. Figure 30 below shows the routing within the survey.

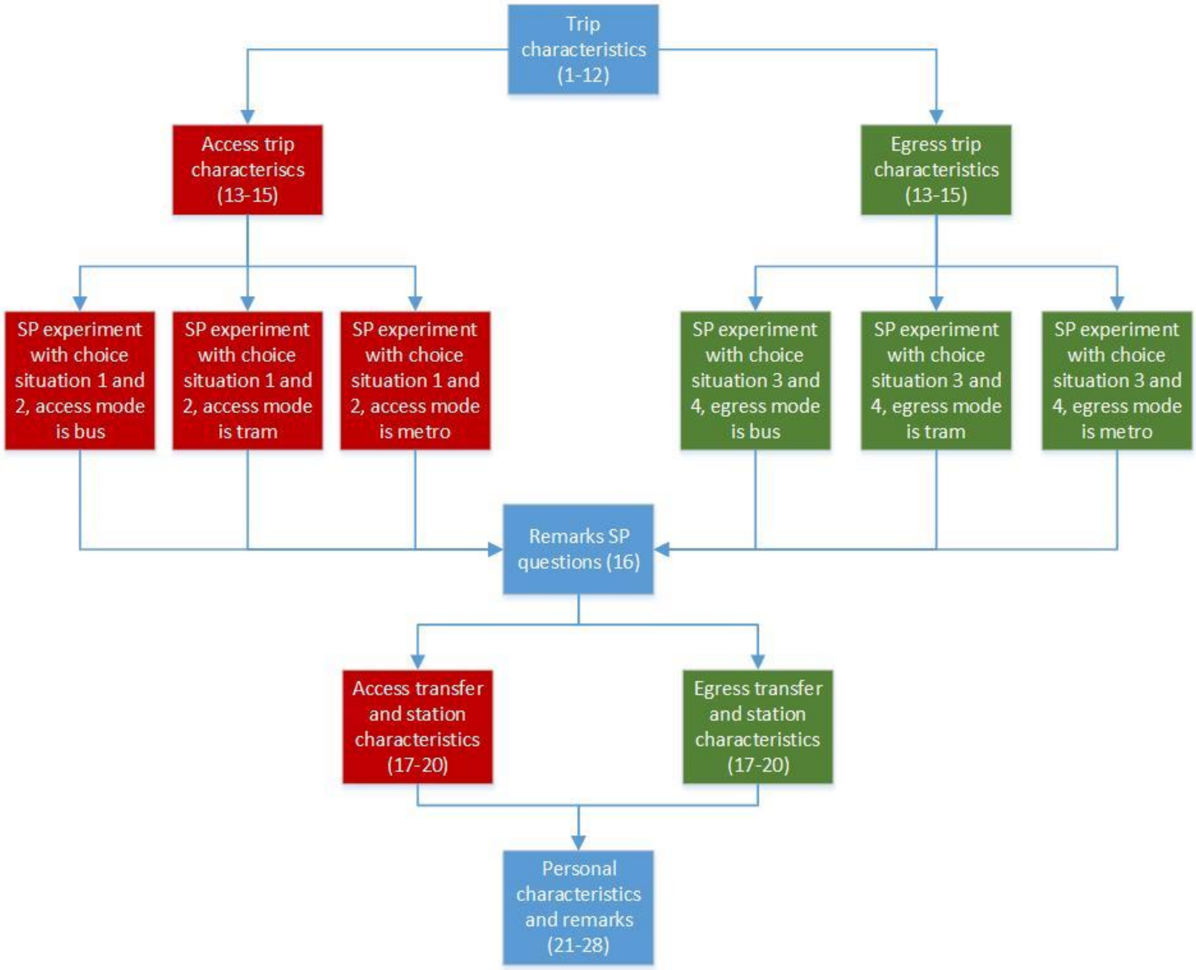


Figure 30: Routing within survey

The full survey questions are included below. Text in red and green gives extra information on the routing or the answer options, but is not shown to the respondent. Text between < > represent a reference to earlier answers. The applicable text is shown to the respondent. Only the plain text is shown in this appendix to save space. The online survey included a more graphical interface.

Text1	Welkom bij dit NS onderzoek over treinreizen in combinatie met de bus, tram of metro. We willen u eerst een aantal vragen stellen over uw algemene reisgedrag en een recente treinreis. Vervolgens leggen we u een aantal keuzesituaties voor waarbij we u vragen uw voorkeur aan te geven. Tot slot zullen er nog enkele algemene vragen gesteld worden. Het invullen van deze enquête duurt ongeveer 10 minuten. Alvast hartelijk bedankt voor uw medewerking aan dit onderzoek. Mocht u tijdens het invullen problemen ondervinden, dan kunt u contact opnemen met Rik Schakenbos, afstudeerder Civiele Techniek van de Universiteit Twente bij NS, via e-mailadres rik.schakenbos@ns.nl.

Number	Question
1	Hoe vaak heeft u de afgelopen 12 maanden gemiddeld met de trein binnen Nederland gereisd? [Single response]
	- 4 dagen per week of vaker -1-3 dagen per week -1-3 dagen per maand -6 - 11 dagen in de afgelopen 12 maanden -3 - 5 dagen in de afgelopen 12 maanden -1 of 2 dagen in de afgelopen 12 maanden -Ik heb de afgelopen 12 maanden niet met de trein binnen Nederland gereisd.

[Routing: If question 1 = option 7, EXIT go to text2, else go to question 2]

Text2	U valt helaas niet binnen de doelgroep van dit onderzoek. De vragenlijst wordt nu beëindigd. Hartelijk dank voor uw medewerking! [EXIT]

Number	Question
2	Wat is voor u meestal de reden om met de trein te reizen? [Single response]
	- Van en naar werk - Zaken-, dienstreis - Van en naar school, studie, opleiding, stage - Bezoek aan familie, vrienden of kennissen - Winkelen - Voor hobby, sport, verenigingsbezoek - Vakantie, uitstapje - Zeer wisselende redenen -Ander doel, namelijk: [open answer question]

Number	Question
3	Hoe vaak heeft u de afgelopen 12 maanden gebruik gemaakt van de bus, tram of metro om vanaf huis naar het station te reizen voor een treinreis? [Single response]
	- (Bijna) nooit -Soms -Vaak - (Bijna) altijd

Number	Question
4	Hoe vaak heeft u de afgelopen 12 maanden gebruik gemaakt van de bus, tram of metro om na een treinreis uw reis te vervolgen? [Single response]

	- (Bijna) nooit -Soms -Vaak - (Bijna) altijd

Number	Question
5	Wat is uw laatst gemaakte treinreis binnen Nederland waarbij u vanaf huis vertrok en gebruik maakte van de bus, tram of metro om naar een treinstation te reizen of om vanaf uw eindstation verder te reizen? [single response]
	- van station <originstation> naar station <destinationstation> - Weet ik niet meer

[Routing: If question 5 = “Weet ik niet meer”, EXIT go to text2, else go to text 3]

Text3	De volgende vragen gaan over uw specifieke reis van station Abcoude naar station Almere Strand. We willen u daarom vragen deze reis in gedachte te houden bij de beantwoording van de vragen.

Number	Question
6	Hoe reisde u naar station <originstation>?[single response] [Answer = <accessmode>]
	-met de bus -met de tram -met de metro -Op een andere manier

Number	Question
7	Hoe reisde u verder vanaf station <destinationstation>? [single response] [Answer = <egressmode>]
	-met de bus -met de tram -met de metro -Op een andere manier

[Routing: If question 6 = “op een andere manier” and question 7 = “op een andere manier” go to text 4, else go to question 8]

Text4	U geeft aan dat u niet met de bus, tram of metro naar station <originstation> bent gereisd en ook niet met de bus, tram of metro vanaf station <destinationstation> verder bent gereisd. We willen u vragen een reis in gedachte te nemen waarbij u van de bus, tram of metro gebruik maakte om naar een treinstation te reizen of om vanaf een treinstation verder te reizen. Routing: Go back to question 5

Number	Question
8	Wat was voor u de reden om deze treinreis te maken tussen station en station <destinationstation>? [Single response] [Answer = <tripmotive>]
	- Van en naar werk - Zaken-, dienstreis - Van en naar school, studie, opleiding, stage - Bezoek aan familie, vrienden of kennissen - Winkelen - Voor hobby, sport, verenigingsbezoek - Vakantie, uitstapje -Andere reden, namelijk: [open answer question]

Assign respondent to category access or egress

Number	Question
9	Hoe lang duurde de treinreis van station <originstation> naar station <destinationstation> met de reden <A18>? *Dit is de totale reistijd van station naar station, inclusief eventuele overstaptijd, volgens de dienstregeling.*[integer]
	-… minuten

Number	Question
10	Met welk type vervoersbewijs maakte u uw treinreis van station <originstation> naar station <destinationstation>? [Single response]
	- Reizen op saldo (OV-chipkaart) of met een kaartje, volledig tarief - Reizen op saldo (OV-chipkaart) of met een kaartje, met korting - Vrij reizen - Vrij reizen op een studenten OV-kaart - Reizen op rekening (Businesscard) - Actiekaartje - Anders namelijk…

Number	Question
11	Wie betaalde uw reiskosten voor deze treinreis van station <originstation> naar station <destinationstation>? [Single response]
	- Ik betaal alles zelf -Ik betaal een deel zelf en een deel wordt door iemand anders betaald -Iemand anders betaalt alles (bijvoorbeeld werkgever of studenten OV-kaart) -Anders, namelijk…. [open answer]

Number	Question
12	Hoeveel kostte de treinreis van station <originstation> naar station <destinationstation> (alleen heenreis)? *Wanneer u niet per enkele reis betaald omdat u bijvoorbeeld een abonnement heeft willen we u vragen een schatting te maken voor de kosten van een enkele reis.* [Number, max 2 decimals]
	-… euro per enkele reis

[Routing: respondents from category egress go to question 13Egress]

Number	Question
13 Access	U gaf aan dat u met de <accessmode> naar station <originstation> bent gereisd. Hoe lang duurde uw reis met de <accessmode> vanaf huis naar station <originstation>? *Ga hierbij uit van de geplande reistijd. Als u het niet meer precies weet, geef dan een benadering.* [Number, only integers]
	-… minuten

Number	Question	Codes
14 Access	Hoeveel heeft u betaald voor uw reis met de <accessmode> vanaf huis naar station <originstation>? *Wanneer u dit niet meer weet, of niet per enkele reis betaalt, maak dan een inschatting voor de kosten van een enkele reis.* [only numbers, max 2 decimals]	

	-… euro	

Number	Question
15 Access	Welke andere mogelijkheden had u redelijkerwijs om naar station <originstation> te reizen? *(Meerdere antwoorden mogelijk)* [Single response first option, multiple response other options.] [Exclude <accessmode> from other choice options]
	-De <accessmode> was voor mij de enige manier om naar station <originstation> te reizen. -met de fiets -lopend -met de bus -met de tram -met de metro -met de trein -met de auto of motor -met de taxi, NS zonetaxi, regiotaxi -anders, namelijk (open answer)

[Routing: go to access SP experiment]

Number	Question
13 Egress	U gaf aan dat u met de <egressmode> verder bent gereisd vanaf station <destinationstation>. Hoe lang duurde deze reis met de <egressmode> vanaf station <destinationstation> naar uw eindbestemming? *Ga hierbij uit van de geplande reistijd. Als u het niet meer precies weet, geef dan een benadering.* [only integers]
	-… minuten

Number	Question
14 Egress	Hoeveel heeft u betaald voor uw reis met de <egressmode> vanaf station <destinationstation> naar uw eindbestemming? *Wanneer u dit niet meer weet, of niet per enkele reis betaalt, maak dan een inschatting voor de kosten van een enkele reis.*[only numbers, max 2 decimals]
	-… euro

Number	Question
15 Egress	Welke andere mogelijkheden had u redelijkerwijs om vanaf station <destinationstation> verder te reizen? (Meerdere antwoorden mogelijk) [Single response first option, multiple response other options.] [Exclude <egressmode> from choice options]
	-Met de <egressmode> was voor mij de enige manier om vanaf station <destinationstation> verder te reizen. -met de fiets -lopend -met de bus -met de tram -met de metro - met de trein -met de auto of motor -met de taxi, NS zonetaxi, regiotaxi -anders, namelijk (open answer)

[Routing: go to Egress SP experiment]

Access SP experiment

We gaan u nu twee keer 6 keuzesituaties voorleggen.

De eerste 6 keuzesituaties beschrijven telkens een fictieve situatie waarin u twee reismogelijkheden krijgt voorgelegd om een reis te maken. In deze keuzesituaties maakt u een reis waarbij u met de metro naar een station (station B) reist. Op dit station stapt u over op de trein om door te reizen naar uw bestemmingsstation (station C). De manier waarop u vanaf uw eindstation verder reist laten we buiten beschouwing. In het onderstaande plaatje is deze reis schematisch weergegeven.

De twee reismogelijkheden worden beschreven door zes kenmerken die verschillende waarden kunnen aannemen per reismogelijkheid. De beschreven kenmerken zijn:

- *Reistijd naar station B:* Dit is de geplande reistijd van metrohalte A naar station B, volgens de dienstregeling.
- *Overstaptijd:* Dit is de tijd tussen de geplande aankomst van de metro en de geplande vertrektijd van de trein. De overstaptijd is dus ook de maximale tijd die u heeft om van de metro naar de trein te lopen. U kunt er vanuit gaan dat bij iedere beschreven overstap een looptijd van 3 minuten wordt gerekend door routeplanners als 9292ov.
- *Reistijd van station B naar station C:* dit is de geplande reistijd van station B naar uw eindstation (station C) volgens de dienstregeling. Het betreft een treinreis zonder overstappen.
- *Frequentie van uw trein van station B naar station C:* Dit is het interval waarmee de trein vertrekt (bijvoorbeeld ieder 15 minuten of iedere 30 minuten).
- *Kosten:* Dit kenmerk geeft de totale kosten weer van uw metroreis plus uw treinreis.
- *Type station:* Dit kenmerk beschrijft de grootte van station B en de aanwezigheid van winkels en restaurants. In de keuzesituaties kunnen drie categorieën voorkomen:
  <u>Middel:</u> Het overstapstation is een gemiddeld station waar één of twee winkeltjes aanwezig zijn om iets te eten of drinken te kopen (zoals bijvoorbeeld een Kiosk). Voorbeelden van dit type station zijn Hoofddorp, Ede-Wageningen en Zaandam.
  <u>Groot:</u> Het overstapstation is een groot station waar drie tot negen winkels aanwezig zijn om iets te eten of te drinken te kopen (zoals Albert Heijn to go, Burger King en Smuller's). Verder zijn er ook enkele winkels met boeken en drogisterijartikelen (zoals Ako en Etos).Voorbeelden van dit type station zijn Leeuwarden, Nijmegen en Haarlem.
  <u>Zeer groot:</u> Het overstapstation is een zeer groot station met tien of meer winkels om iets te eten of drinken te kopen (zoals bijvoorbeeld Burger King, Starbucks, Julia's). Verder is er een groot aanbod aan winkels met non-food artikelen (zoals bijvoorbeeld Hema, Etos, Ako, Rituals). Voorbeelden van dit type station zijn Amsterdam Centraal, Utrecht Centraal en Rotterdam Centraal.

U mag er vanuit gaan dat alle niet beschreven kenmerken van de reizen, voor beide mogelijkheden gelijk zijn. Wanneer de twee beschreven reismogelijkheden voor u zo slecht zijn dat u deze reis niet zou maken kunt u aangeven dat u op een andere manier naar station B zou reizen of helemaal niet met de trein zou reizen.

First serie of 6 choice situations will be presented. Attribute levels according to one block from the SP design in appendix B.

We willen u nog zes keuzesituaties voorleggen. Nu heeft u behalve de mogelijkheid om per <accessmode> naar station B te reizen ook de mogelijkheid om per trein naar station B te reizen. U bevindt zich thuis en <accessmode>halte A en treinstation A liggen naast elkaar, op loopafstand van uw huis. Vanaf station B reist u verder per trein naar uw bestemmingsstation. In het onderstaande plaatje zijn beide reismogelijkheden schematisch weergegeven. De manier waarop u vanaf uw bestemmingsstation verder reist laten we buiten beschouwing. De reismogelijkheden worden beschreven door dezelfde kenmerken als in de vorige keuzesituaties.

Second serie of 6 choice situations will be presented. Attribute levels according to one block from the SP design in appendix B.

[Routing: go to question 16]

Egress SP experiment

We gaan u nu twee keer 6 keuzesituaties voorleggen.

De eerste 6 keuzesituaties beschrijven telkens een fictieve situatie waarin u twee reismogelijkheden krijgt voorgelegd om een reis te maken. U maakt een reis waarbij u met de trein reist van een station (station A) naar een ander station (station B). Op station B stapt u over op de <egressmode> om door te reizen naar uw eindbestemming.
De twee reismogelijkheden worden beschreven door zes kenmerken die verschillende waarden kunnen aannemen per reismogelijkheid. De beschreven kenmerken zijn:

De twee reismogelijkheden worden beschreven door zes kenmerken die verschillende waarden kunnen aannemen per reismogelijkheid. De beschreven kenmerken zijn:

- *Reistijd naar station B:* Dit is de geplande reistijd van metrohalte A naar station B, volgens de dienstregeling.
- *Overstaptijd:* Dit is de tijd tussen de geplande aankomst van de metro en de geplande vertrektijd van de trein. De overstaptijd is dus ook de maximale tijd die u heeft om van de metro naar de trein te lopen. U kunt er vanuit gaan dat bij iedere beschreven overstap een looptijd van 3 minuten wordt gerekend door routeplanners als 9292ov.
- *Reistijd van station B naar station C:* dit is de geplande reistijd van station B naar uw eindstation (station C) volgens de dienstregeling. Het betreft een treinreis zonder overstappen.
- *Frequentie van uw trein van station B naar station C:* Dit is het interval waarmee de trein vertrekt (bijvoorbeeld ieder 15 minuten of iedere 30 minuten).
- *Kosten:* Dit kenmerk geeft de totale kosten weer van uw metroreis plus uw treinreis.
- *Type station:* Dit kenmerk beschrijft de grootte van station B en de aanwezigheid van winkels en restaurants. In de keuzesituaties kunnen drie categorieën voorkomen:
  Middel: Het overstapstation is een gemiddeld station waar één of twee winkeltjes aanwezig zijn om iets te eten of drinken te kopen (zoals bijvoorbeeld een Kiosk). Voorbeelden van dit type station zijn Hoofddorp, Ede-Wageningen en Zaandam.
  Groot: Het overstapstation is een groot station waar drie tot negen winkels aanwezig zijn om iets te eten of te drinken te kopen (zoals Albert Heijn to go, Burger King en Smuller's). Verder zijn er ook enkele winkels met boeken en drogisterijartikelen (zoals Ako en Etos).Voorbeelden van dit type station zijn Leeuwarden, Nijmegen en Haarlem.
  Zeer groot: Het overstapstation is een zeer groot station met tien of meer winkels om iets te eten of drinken te kopen (zoals bijvoorbeeld Burger King, Starbucks, Julia's). Verder is er een groot aanbod aan winkels met non-food artikelen (zoals bijvoorbeeld Hema, Etos, Ako, Rituals). Voorbeelden van dit type station zijn Amsterdam Centraal, Utrecht Centraal en Rotterdam Centraal.

U mag er vanuit gaan dat alle niet beschreven kenmerken van de reizen, voor beide mogelijkheden gelijk zijn. Wanneer de twee beschreven reismogelijkheden voor u zo slecht zijn dat u deze reis niet zou maken kunt u aangeven dat u op een andere manier naar station B zou reizen of helemaal niet met de trein zou reizen.

First serie of 6 choice situations will be presented. Attribute levels according to one block from the SP design in appendix B.

We willen u nog zes keuzesituaties voorleggen. U reist weer per trein van station A naar station B. Dit keer heeft u vervolgens de keuze om per <egressmode> of per trein naar uw eindbestemming te reizen. In het onderstaande plaatje zijn beide opties schematisch weergegeven. De reismogelijkheden worden beschreven door dezelfde kenmerken als in de vorige keuzesituaties.

Second serie of 6 choice situations will be presented. Attribute levels according to one block from the SP design in appendix B.

Number	Question
16	Dit waren alle keuzesituaties. Heeft u opmerkingen over dit onderdeel van de enquête?
	[textbox, not mandatory]

[Routing: respondents from category egress go to question 17Egress]

Text4	Voor we de enquête afsluiten met een aantal algemene vragen, zouden we nog graag enkele aanvullende vragen stellen over uw reis van station <originstation> naar station <destinationstation>. Hierbij reisde u met als reden <A18>.

Number	Question
17 Access	Op de door u beschreven reis stapte u over van de <accessmode> naar de trein op station <originstation>. Kunt u een inschatting geven van de overstaptijd (de tijd tussen de geplande aankomst van de <accessmode> en het vertrek van de trein)? [only integers]
	-… minuten - Weet ik echt niet meer

Number	Question
18 Access	Wat is voor u de ideale overstaptijd (de tijd tussen de geplande aankomst van de <accessmode> en het vertrek van de trein) bij deze overstap op station <originstation>? [only integers]
	-… minuten - Toelichting (niet verplicht)…

Number	Question
19 Access	Hoe vaak reed de trein waarop u overstapte op station <originstation>? *Wanneer u dit niet meer precies weet, probeer dan een inschatting te geven.* [only integers]
	-Om de … minuten - Weet ik echt niet meer

Number	Question
20 Access	Wat is uw oordeel over de volgende aspecten, uitgedrukt in een rapportcijfer (1-10)? [Table with assessment possiblities 1-10 and no answer]
	- Algemeen oordeel over station <originstation> - Station <originstation> als plaats om comfortabel te wachten - Veiligheid op station <originstation> - Overzicht op station <originstation> - Aanwezigheid van winkels (food en non-food) op station <originstation> - Snelheid waarmee u bij uw trein kon komen

[Routing: go to question 21]

Number	Question
17 Egress	Op de door u beschreven reis stapte u over van de trein op de <egressmode> op station <destinationstation>. Kunt u een inschatting geven van de overstaptijd (de tijd tussen de geplande aankomst van de trein en het vertrek van de <egressmode>)? [only integers]
	-… minuten - Weet ik echt niet meer

Number	Question
18 Egress	Wat is voor u de ideale overstaptijd (de tijd tussen de geplande aankomst van de trein en het vertrek van de <egressmode>) bij deze overstap op station <originstation>? [only integers]
	-… minuten - Toelichting (niet verplicht)..

Number	Question
19 Egress	Hoe vaak reed de <egressmode> waarop u overstapte op station <destinationstation>? *Wanneer u dit niet meer precies weet, probeer dan een inschatting te geven.* [only integers]
	- om de … minuten - Weet ik echt niet meer

Number	Question
20 Egress	Wat is uw oordeel over de volgende aspecten, uitgedrukt in een rapportcijfer (1-10)? [Table with assessment possiblities 1-10 and no answer]
	- Algemeen oordeel over station <destinationstation> - In hoeverre is station <destinationstation> een aangename verblijfplaats - Veiligheid op station <destinationstation> - Overzicht op station <destinationstation> - Aanwezigheid van winkels (food en non-food) op station <destinationstation> - Snelheid waarmee u bij uw <A7A> kon komen

Text5	Nu volgen een aantal laatste vragen.

Number	Question
21	Bent u… [single response]
	- een man - een vrouw

Number	Question
22	Wat is uw leeftijd? [single response]
	- Jonger dan 18 jaar - 18-29 jaar - 30-39 jaar - 40-49 jaar - 50-59 jaar -60-69 jaar - 70 jaar of ouder Wil ik niet zeggen

Number	Question
23	Welke van de volgende categorieën beschrijft uw situatie het beste? [single response]
	- Studerend, schoolgaand - Deeltijds werkend - Voltijds werkend - Niet werkend - Gepensioneerd - Anders namelijk… - Wil ik niet zeggen

Number	Question
24	Hoeveel bedraagt uw maandelijkse bruto inkomen? *Dit betreft inkomen uit arbeid, inkomen uit eigen onderneming, uitkering inkomensverzekeringen en uitkering sociale voorzieningen (m.u.v. kinderbijslag).*[single response]
	- Minder dan € 1000 - € 1000 - € 1999 - € 2000 - € 2999 - € 3000 - € 3999 - € 4000 - € 4999 - € 5000 - € 5999 - € 6000 of meer - Dat wil ik niet zeggen / dat weet ik niet

Number	Question
25	Wat is uw hoogst genoten afgeronde opleiding? [Single response]
	- Basisschool -LBO, MAVO, VMBO -HAVO, VWO -MBO -HBO -WO - anders, namelijk… - Dat wil ik niet zeggen

Number	Question
26	Wat zijn de eerste vier cijfers van uw postcode? [integer, 4 numbers]
	…. -Dat wil ik niet zeggen

Number	Question
27	Wilt u nog iets kwijt over een overstap tussen de bus/tram/metro en de trein?
	[textbox, not mandatory]

Number	Question
28	Heeft u nog opmerkingen over deze enquête?
	[textbox, not mandatory]

Text5	Dit waren alle vragen. Hartelijk dank voor het invullen van deze enquête! U kunt dit venster nu sluiten, of klik hier om naar de website van het NSpanel te gaan. [EXIT]

Appendix B: Experiment design for choice experiment

Table 37: Choice experiment design

		Choice option 1						Choice option 2					
Block	Card	AET 1	TT1	ITT1	CO1	HW1	SF1	AET 2	TT2	ITT2	CO2	HW2	SF2
Block 1	1	RP -10%	3	RP +-0%	RP +10%	15	medium	RP +10%	5	RP -20%	RP -10%	30	very large
	2	RP +20%	8	RP +20%	RP -20%	20	medium	RP +10%	11	RP +10%	RP +-0%	30	large
	3	RP +-0%	8	RP -20%	RP +20%	15	very large	RP -10%	3	RP +-0%	RP -10%	20	large
	4	RP -20%	11	RP +20%	RP +-0%	15	large	RP +-0%	5	RP +10%	RP -20%	20	very large
	5	RP +10%	3	RP -10%	RP +20%	20	very large	RP -20%	8	RP +10%	RP -10%	15	medium
	6	RP +10%	15	RP -10%	RP +-0%	30	medium	RP +20%	3	RP +10%	RP +20%	20	large
Block 2	7	RP -10%	15	RP +20%	RP +20%	30	medium	RP +10%	3	RP -10%	RP +10%	15	very large
	8	RP +20%	11	RP +-0%	RP +20%	15	large	RP +-0%	3	RP +20%	RP +-0%	30	medium
	9	RP -20%	15	RP +-0%	RP -10%	20	very large	RP +20%	8	RP -10%	RP -20%	30	large
	10	RP +-0%	3	RP +20%	RP -10%	20	large	RP -20%	11	RP +-0%	RP +20%	30	very large
	11	RP -20%	3	RP -20%	RP -20%	15	medium	RP +10%	15	RP +-0%	RP -20%	20	medium
	12	RP +10%	5	RP +20%	RP +10%	30	very large	RP +-0%	15	RP -20%	RP +20%	15	large
Block 3	13	RP +-0%	11	RP +10%	RP +10%	20	very large	RP -10%	5	RP -10%	RP +20%	15	medium
	14	RP +20%	5	RP -10%	RP -10%	15	medium	RP -10%	15	RP +10%	RP +10%	30	very large
	15	RP -20%	8	RP -10%	RP +10%	30	large	RP +20%	5	RP +-0%	RP +10%	15	very large
	16	RP +20%	3	RP +10%	RP +-0%	30	very large	RP +10%	8	RP +20%	RP +20%	20	medium
	17	RP +10%	15	RP +10%	RP -20%	15	large	RP +20%	11	RP -20%	RP +10%	20	medium
	18	RP -10%	11	RP -10%	RP -20%	30	very large	RP -20%	3	RP -20%	RP -20%	15	medium
Block 4	19	RP -10%	5	RP -20%	RP +-0%	20	large	RP +20%	15	RP +20%	RP -10%	15	very large
	20	RP -20%	5	RP +10%	RP +20%	20	medium	RP -10%	11	RP +20%	RP -20%	15	large
	21	RP +20%	15	RP -20%	RP +10%	20	large	RP +-0%	11	RP -10%	RP -10%	30	medium
	22	RP +10%	11	RP -20%	RP -10%	30	medium	RP -20%	15	RP -10%	RP +-0%	20	large
	23	RP -10%	8	RP +10%	RP -10%	15	very large	RP -20%	5	RP +20%	RP +10%	30	large
	24	RP +-0%	5	RP +-0%	RP -20%	30	large	RP -10%	8	RP -20%	RP +-0%	20	very large

AET = Access/Egress trip time
TT = transfer time
ITT = In-train trip time
CO = Costs
HW = Headway of connecting mode
SF = Station facilities. ‘
RP = Reported attribute value in RP trip

Attributes indicated in red are overlapping.

Appendix C: Statistics on exclusion criteria

SP experiment completion time

Figure 31 shows the time needed by the respondents to complete the SP experiment, grouped in 30 seconds intervals. Respondents who needed less than 1.5 minutes (indicated in red) are excluded from the dataset.

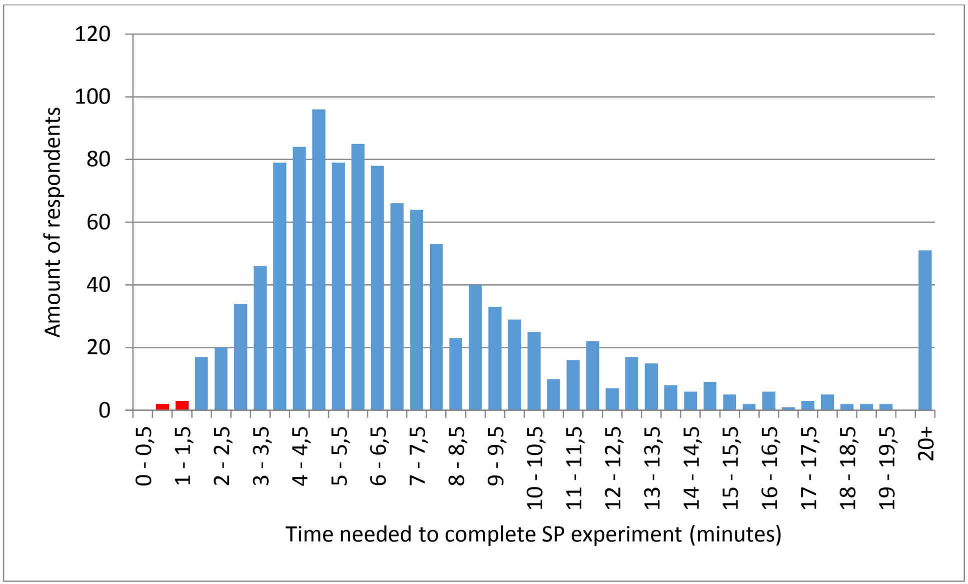


Figure 31: Distribution of time needed to complete the SP experiment

Survey completion time

Figure 32 shows the amount of time that was needed for the respondents to complete the entire survey, grouped in one-minute intervals. Respondents who needed less than 5 minutes (indicated in red) are excluded from the dataset.

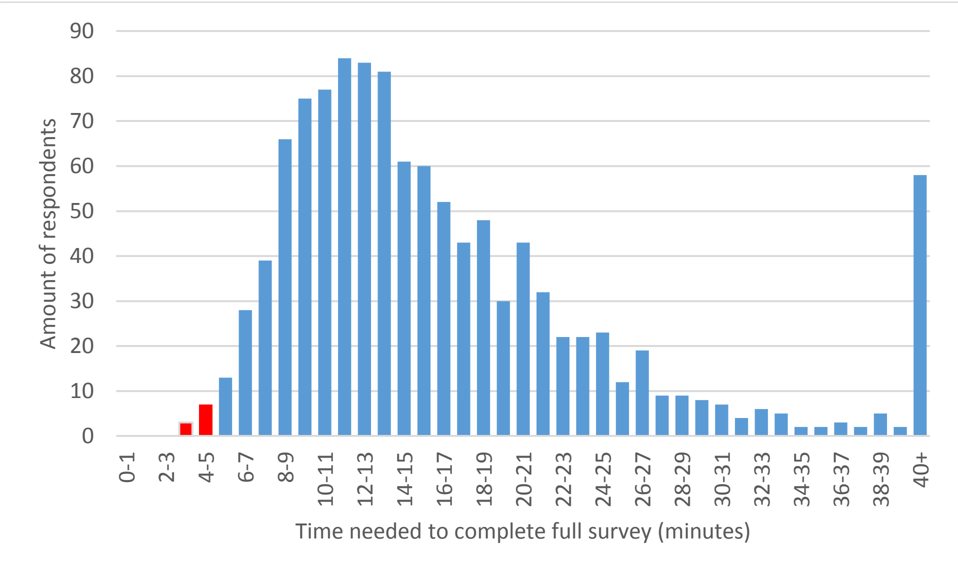


Figure 32: Distribution of time needed to complete full survey

Cost estimations

Figure 33 and Figure 34 below show the costs estimations for the BTM trip and the train trip. For the BTM costs estimations, respondents with an estimation below €0,50 or above €10,00 (indicated in red) are excluded from the dataset. For train costs estimations, respondents with an estimation below €1,30 and above €60 (indicated in red) are removed from the dataset.

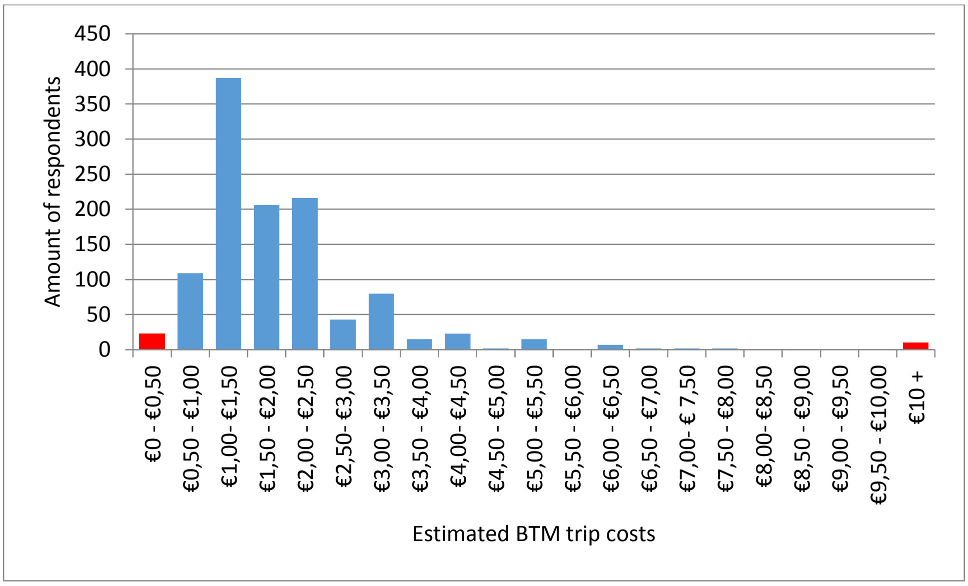


Figure 33: Distribution of cost estimation BTM trip

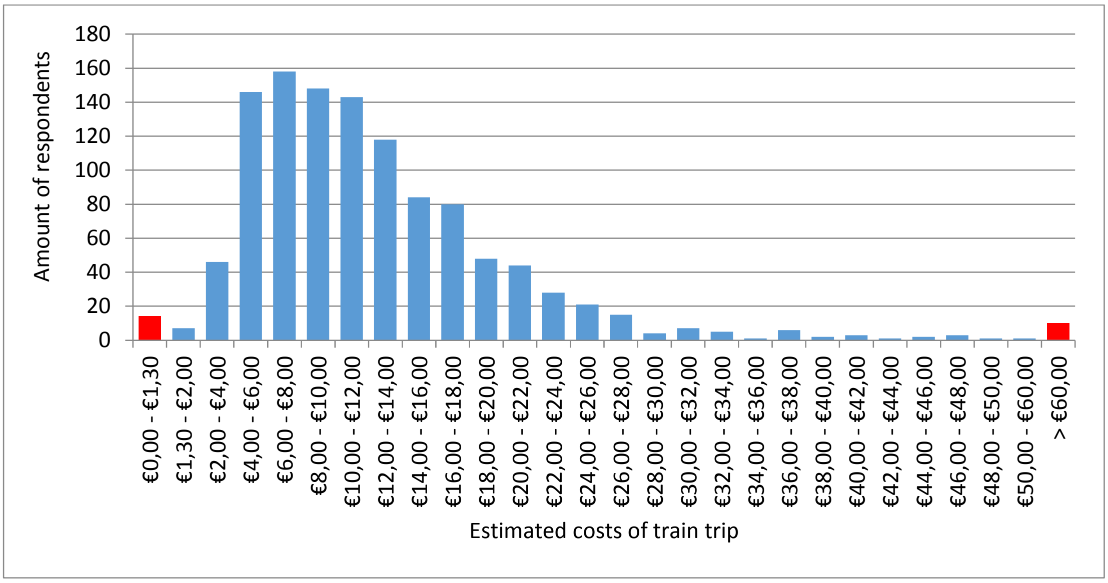


Figure 34: Distribution of cost estimation train trip

Trip time estimation BTM trip

Figure 35 below shows the estimated BTM trip time grouped in 5 minute intervals. Respondents with an estimation above 60 minutes (indicated in red) are excluded from the dataset.

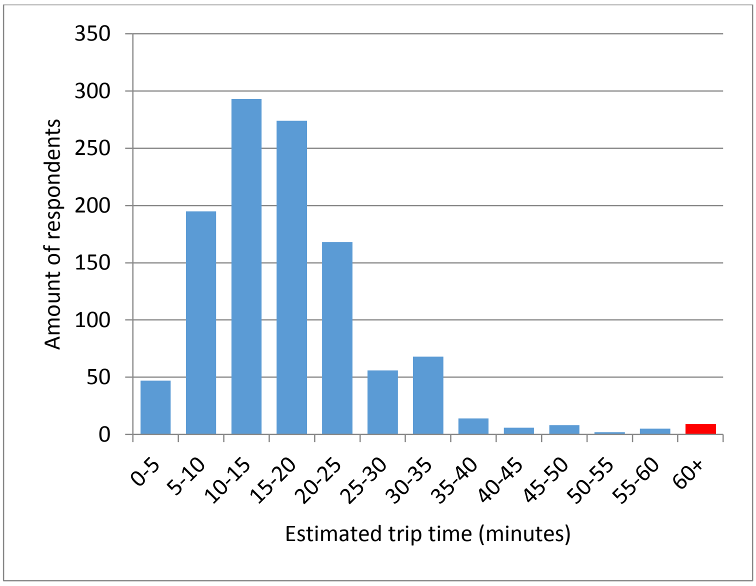


Figure 35: Distribution of estimated trip time BTM trip

Trip time estimations train trip

Figure 36 shows the estimated train trip time grouped in ten minute intervals.

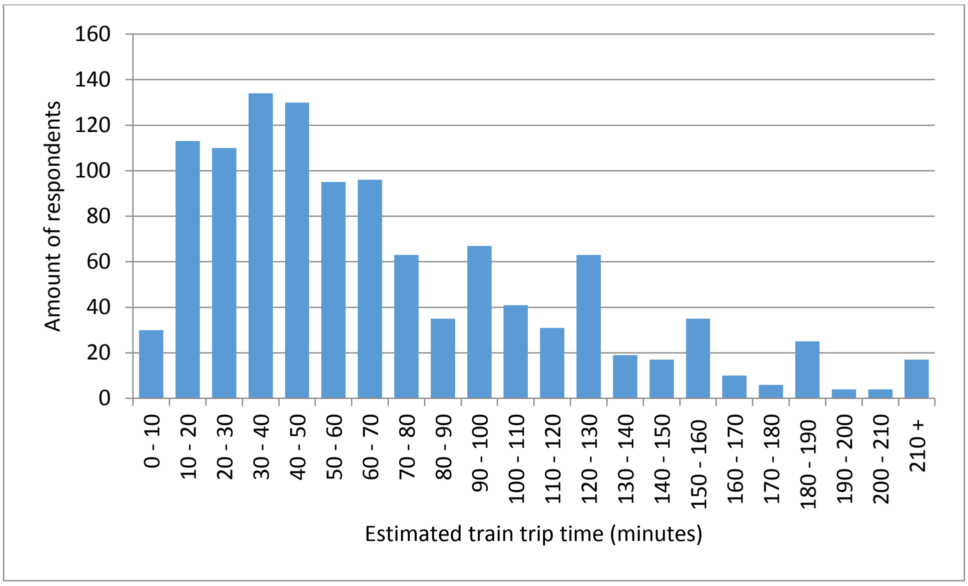


Figure 36: Distribution of trip time estimation train trip

In Figure 37 below, each estimated trip time is plotted against the real average trip time. It is shown which respondents are excluded as well.

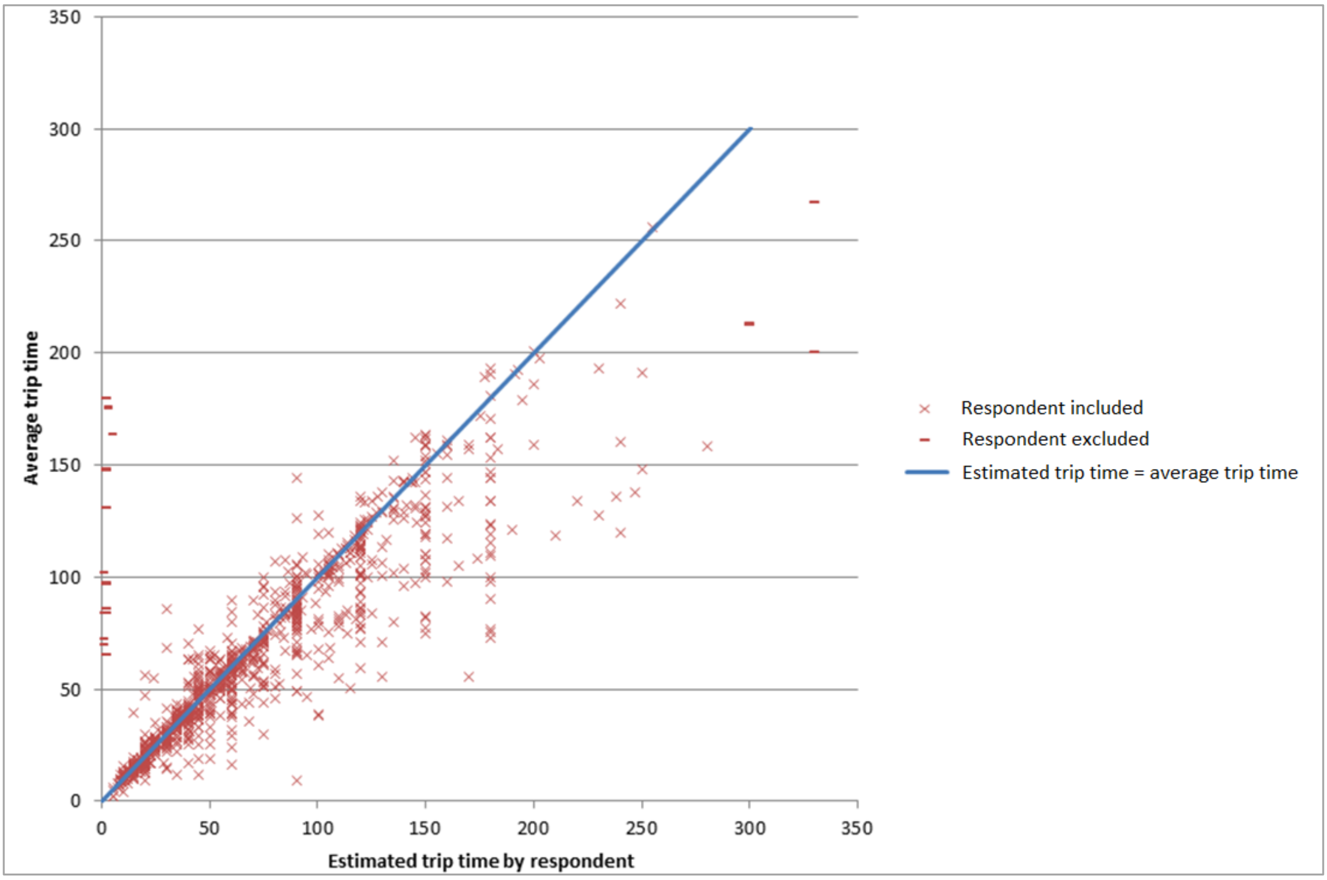


Figure 37: Estimated trip time plotted against the average scheduled trip time in reality

Appendix D: Sample characteristics

Table 38 below shows the sample characteristics for several socioeconomic characteristics and travel characteristics. The real distribution of these characteristics within the NS population is added as well when this is known. The NS population is defined as all travelers who traveled with NS in the reference year. The real distribution is based on large internal research by NS (Climate IV).

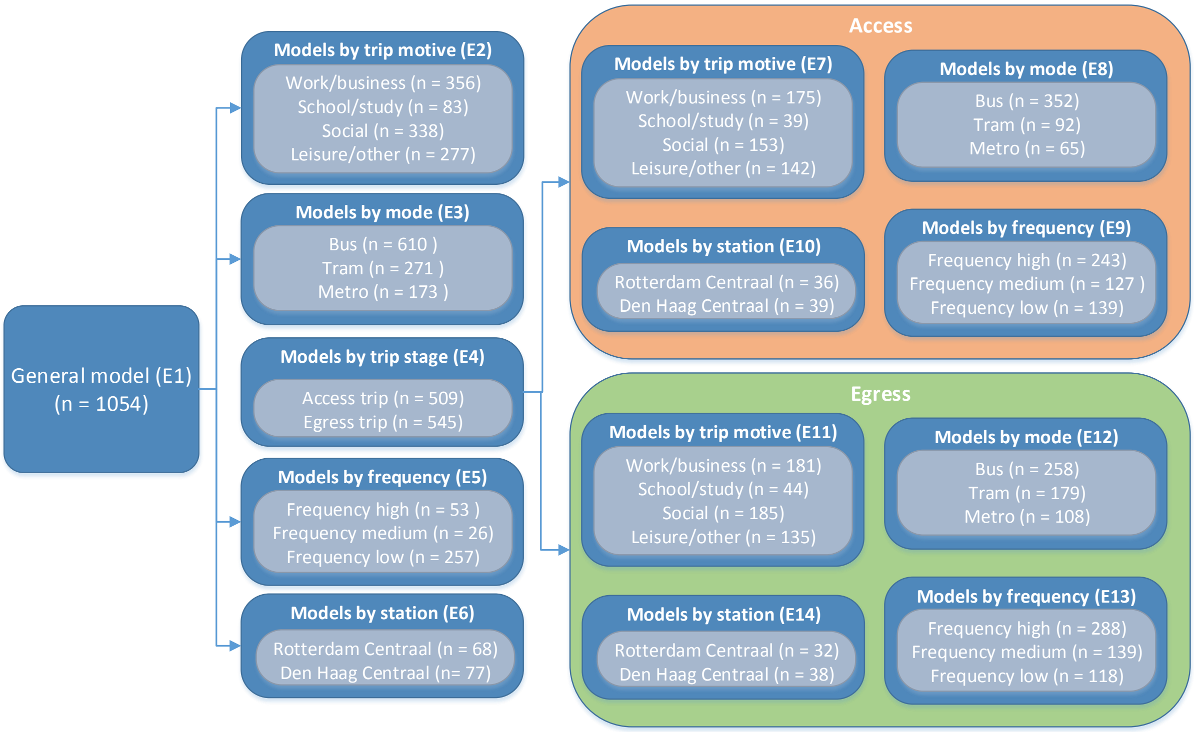
Table 38: Overview of sample characteristics

	Distribution within sample Absolute	 %	Real distribution NS population (trips 2010) Percentage
Trip motive indicated trip			
Work/business	361	34%	45%
School/Study	83	8%	31%
Social/recreational/other	341	32%	11%
Recreational/other	279	26%	13%
Travel frequency train			
Once per week or more	535	50%	77%
1-3 times a month	268	25%	10%
Less than once a month	261	25%	13%
Travel frequency BTM as access mode to station			
(Almost) never	344	32%	-
Sometimes	166	16%	-
Often	169	16%	-
(Almost) always	385	36%	-
Travel frequency BTM as egress from station			
(Almost) never	134	13%	-
Sometimes	288	27%	-
Often	270	25%	-
(Almost) always	372	35%	-
Access mode indicated trip (total)			
Bus	440	41%	-
Tram	111	10%	-
Metro	81	8%	-
Other	432	41%	-
Egress mode indicated trip (total)			
Bus	365	34%	-
Tram	232	22%	-
Metro	131	12%	-
Other	336	32%	-
Access mode indicated trip (access group)			
Bus	356	69%	-
Tram	94	18%	-
Metro	65	13%	-
Egress mode indicated trip (egress group)			
Bus	260	47%	-
Tram	181	33%	-
Metro	108	20%	-
Type of train ticket indicated trip			
Travel on balance with OV chipcard or single ticket, no discount	120	11%	26%
Travel on balance with OV chipcard or	483	45%	22%

single ticket, with discount				
Free travel	306	29%	48%	
Businesscard	78	7%	2%	
Special action ticket	69	6%	3%	
Other	8	1%		
Who paid for the indicated trip				
Traveler paid himself	677	64%	-	
Traveler partly paid himself	89	8%	-	
Someone else paid	284	27%	-	
Other	14	1%	-	
Gender				
Male	555	52%	51%	
Female	509	48%	49%	
Age				
Under 18 years	4	0%	Under 18 years	5%
18 - 29 years	186	17%	18 - 24 years	37%
30 – 39 years	111	10%	25 - 34 years	21%
40 – 49 years	136	13%	35 - 44 years	14%
50 – 59 years	221	21%	45 - 54 years	12%
60 – 69 years	286	27%	55 - 64 years	6%
70 years or older	114	11%	65+ years	4%
Unknown	6	1%		
Working situation				
Studying	109	10%	-	
Parttime working	196	18%	-	
Fulltime working	400	38%	-	
Not working	77	7%	-	
Retired	260	24%	-	
Other	6	1%	-	
Unknown	16	2%	-	
Monthly gross income				
Less than €1000	142	13%	-	
€1000 - € 1999	184	17%	-	
€ 2000 - €2999	187	18%	-	
€ 3000 - €3999	127	12%	-	
€ 4000 - € 4999	77	7%	-	
€ 5000 - €5999	40	4%	-	
€ 6000 or more	37	3%	-	
Unknown	270	25%	-	
Highest completed education				
Primary school / none	7	1%	15%	
MAVO / VMBO / MBO	223	21%	20%	
HAVO / VWO	151	14%	22%	
HBO / WO	649	61%	43%	
Unknown/other	34	3%		
Region place of residence				
Amsterdam, Rotterdam, Den Haag	210	20%	15%	
Other West	344	32%	37%	
North	50	5%	6%	
East	182	17%	22%	
South	164	15%	19%	
Unknown	114	11%	-	

Appendix E: Parameter values for sub models

This appendix provides the model estimations of the different models as discussed in section 5.1.9. The overview of the different estimated models is provided below. The numbers between brackets in the titles show in which part of this appendix, the specific model can be found.



Appendix E1: General model MNL and ML

Parameter	General model MNL Value	Std error	t-test	GTT	General model ML Value	Std error	t-test	GTT
ASC BTM-Train	-0.191	0.103	-1.85	3.8	-0.256	0.118	-2.18	4.7
ASC train-train	0	fixed			0	fixed		
Access time by bus	-0.0585	0.00457	-12.80	1.2	-0.0629	0.00549	-11.45	1.2
Egress time by bus	-0.0702	0.00488	-14.40	1.4	-0.0749	0.00592	-12.65	1.4
Access time by tram/metro	-0.0427	0.00657	-6.50	0.8	-0.0454	0.00841	-5.41	0.8
Egress time by tram/metro	-0.0417	0.006	-6.95	0.8	-0.0421	0.00752	-5.60	0.8
Costs, someone else pays, income < €2000	-0.341	0.0192	-17.71	6.7	-0.362	0.02	-18.14	6.7
Costs, someone else pays, income €2000 - €3000	-0.17	0.0407	-4.17	3.4	-0.174	0.043	-4.05	3.2
Costs, someone else pays, income €3000 - €6000	-0.167	0.0167	-10.04	3.3	-0.179	0.0174	-10.34	3.3
Costs, someone else pays, income > €6000	-0.0488	0.0285	-1.71	1.0	-0.05	0.0305	-1.64	0.9
Costs, traveler pays, income < €2000	-0.607	0.0303	-20.04	12.0	-0.647	0.0313	-20.69	12.0
Costs, traveler pays, income €2000 - €3000	-0.438	0.0347	-12.59	8.6	-0.46	0.0365	-12.62	8.5
Costs, traveler pays, income €3000 - €6000	-0.297	0.0191	-15.52	5.9	-0.315	0.0203	-15.54	5.8
Costs, traveler pays, income > €6000	-0.11	0.0427	-2.57	2.2	-0.114	0.0442	-2.57	2.1
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.287	0.0343	-8.36	5.7	-0.308	0.0357	-8.61	5.7
Headway connecting mode 30 minutes	-0.553	0.0361	-15.31	10.9	-0.593	0.0376	-15.77	11.0
In-train time	-0.0507	0.00278	-18.23	1.0	-0.054	0.00292	-18.51	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00122	0.00378	0.32	0.0	0.00057	0.00392	0.14	0.0
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.0423	0.0296	1.43	-0.8	0.0447	0.0309	1.45	-0.8
Transfer time of 3 minutes BTM-train	-0.392	0.0885	-4.43	7.7	-0.427	0.0922	-4.64	7.9
Transfer time of 5 minutes BTM-train	-0.34	0.0822	-4.14	6.7	-0.385	0.0867	-4.44	7.1
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.66	0.0597	-11.04	13.0	-0.7	0.0617	-11.34	13.0
Transfer time of 15 minutes BTM-train	-0.975	0.06	-16.25	19.2	-1.02	0.0616	-16.61	18.9
Transfer time of 3 minutes train-train	-0.4	0.128	-3.13	7.9	-0.466	0.136	-3.43	8.6
Transfer time of 5 minutes train-train	-0.284	0.122	-2.33	5.6	-0.35	0.131	-2.67	6.5
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.524	0.11	-4.75	10.3	-0.593	0.117	-5.08	11.0
Transfer time of 15 minutes train-train	-1.09	0.109	-10.07	21.5	-1.24	0.117	-10.64	23.0
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.399	0.0873	-4.57	7.9	-0.421	0.091	-4.63	7.8
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.377	0.0829	4.55	-7.4	0.411	0.0867	4.74	-7.6
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.32	0.0788	4.06	-6.3	0.358	0.0843	4.25	-6.6
Sigma BTM-train	0	0	0.00		0.006	0.083	0.07	
Sigma train-train	0	0	0.00		0.795	0.0533	14.92	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.659	0.0414	-8.24		0.659	0.041	-8.24	
Null log-likelihood	-8331.24				-8331.24			
Final log-likelihood	-6678.576	0	0.00		-6621.04			
Adjusted ρ^2	0.195	0	0.00		0.202			

Appendix E2: General model by trip motive

Parameter	Work/business total				School/study total			
	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	-0.203	0.195	-1.04	2.8	-0.595	0.396	-1.50	14.8
ASC train-train	0	fixed			0	fixed		0.0
Access time by bus	-0.0813	0.0106	-7.66	1.1	-0.053	0.016	-3.40	1.3
Egress time by bus	-0.115	0.0114	-10.01	1.6	-0.038	0.017	-2.28	1.0
Access time by tram/metro	-0.0565	0.0146	-3.88	0.8	-0.06	0.031	-1.93	1.5
Egress time by tram/metro	-0.055	0.0135	-4.08	0.8	-0.043	0.026	-1.64	1.1
Costs, someone else pays, income < €2000	-0.179	0.0586	-3.05	2.5	-0.369	0.046	-8.00	9.2
Costs, someone else pays, income €2000 - €3000	-0.179	0.0538	-3.33	2.5	-0.26	0.285	-0.91	6.5
Costs, someone else pays, income €3000 - €6000	-0.152	0.022	-6.92	2.1	-0.636	0.155	-4.12	15.8
Costs, someone else pays, income > €6000	-0.0687	0.0372	-1.84	0.9	0	-	0.00	0.0
Costs, traveler pays, income < €2000	-0.683	0.0956	-7.15	9.4	-0.66	0.09	-7.36	16.4
Costs, traveler pays, income €2000 - €3000	-0.405	0.0525	-7.71	5.6	-1.34	0.436	-3.08	33.3
Costs, traveler pays, income €3000 - €6000	-0.271	0.0285	-9.53	3.7	-0.479	0.2	-2.40	11.9
Costs, traveler pays, income > €6000	-0.106	0.0544	-1.95	1.5	0	-	0.00	0.0
Frequency connecting mode 15 minutes	0	fixed			0	fixed		0.0
Headway connecting mode 20 minutes	-0.36	0.0611	-5.89	4.9	-0.254	0.121	-2.09	6.3
Headway connecting mode 30 minutes	-0.76	0.0643	-11.82	10.4	-0.471	0.127	-3.70	11.7
In-train time	-0.0728	0.0054	-13.59	1.0	-0.04	0.009	-4.28	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00135	0.0082	0.17	0.0	-0.01	0.013	-0.79	0.3
Transfer station medium/large	0	fixed			0	fixed		0.0
Transfer station very large	0.0339	0.0515	0.66	-0.5	0.023	0.105	0.22	-0.6
Transfer time of 3 minutes BTM-train	-0.144	0.178	-0.81	2.0	-0.505	0.371	-1.36	12.6
Transfer time of 5 minutes BTM-train	-0.245	0.176	-1.39	3.4	-0.516	0.322	-1.60	12.8
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		0.0
Transfer time of 11 minutes BTM-train	-0.72	0.1	-7.19	9.9	-0.625	0.215	-2.91	15.5
Transfer time of 15 minutes BTM-train	-1.02	0.1	-10.21	14.0	-1.09	0.215	-5.07	27.1
Transfer time of 3 minutes train-train	0.196	0.244	0.80	-2.7	-1.48	0.505	-2.94	36.8
Transfer time of 5 minutes train-train	-0.117	0.236	-0.50	1.6	-0.843	0.466	-1.81	21.0
Transfer time of 8 minutes train-train	0	fixed			0	fixed		0.0
Transfer time of 11 minutes train-train	-0.598	0.189	-3.17	8.2	-0.921	0.416	-2.21	22.9
Transfer time of 15 minutes train-train	-1.31	0.199	-6.61	18.0	-1.3	0.386	-3.37	32.3
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.393	0.145	-2.72	5.4	-1.42	0.567	-2.51	35.3
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.185	0.171	1.09	-2.5	0.553	0.36	1.53	-13.8
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.261	0.171	1.52	-3.6	0.535	0.31	1.73	-13.3
Sigma BTM-train	0.02	0.191	-0.10		0.0059	0.199	-0.03	
Sigma train-train	0.885	0.0982	9.02		0.571	0.21	2.72	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			-			
Scale parameter in-train time RP trip > 70 minutes	1.160	0.230	0.69		-			
Null log-likelihood	-2776.05				-659.88			
Final log-likelihood	-2139.822				-488.8			
Adjusted ρ^2	0.218				0.212			

Parameter	Social total Value	Std error	t-test	GTT	Recreational/other total Value	Std error	t-test	GTT
ASC BTM-Train	0.127	0.233	0.55	-2.3	0.236	0.219	1.08	-6.2
ASC train-train	0	fixed			0	fixed		
Access time by bus	-0.0635	0.0118	-5.39	1.1	-0.0552	0.0105	-5.27	1.5
Egress time by bus	-0.0948	0.0115	-8.27	1.7	-0.0633	0.0115	-5.49	1.7
Access time by tram/metro	-0.033	0.014	-2.35	0.6	-0.0378	0.0118	-3.21	1.0
Egress time by tram/metro	-0.0397	0.0126	-3.16	0.7	-0.0644	0.0126	-5.09	1.7
Costs, someone else pays, income < €2000	-0.723	0.0836	-8.65	13.1	-0.258	0.104	-2.48	6.8
Costs, someone else pays, income €2000 - €3000					-0.559	0.302	-1.85	14.7
Costs, someone else pays, income €3000 - €6000	-0.242	0.0774	-3.13	4.4	-0.203	0.0877	-2.31	5.4
Costs, someone else pays, income > €6000								
Costs, traveler pays, income < €2000	-0.574	0.0408	-14.09	10.4	-0.527	0.0444	-11.87	13.9
Costs, traveler pays, income €2000 - €3000	-0.476	0.0496	-9.59	8.6	-0.408	0.0458	-8.91	10.8
Costs, traveler pays, income €3000 - €6000	-0.423	0.0339	-12.49	7.6	-0.323	0.0252	-12.81	8.5
Costs, traveler pays, income > €6000	-0.23	0.0933	-2.47	4.2	-0.777	2.09E-01	-3.71	20.5
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.306	0.0656	-4.66	5.5	-0.172	0.0619	-2.78	4.5
Headway connecting mode 30 minutes	-0.476	0.0701	-6.79	8.6	-0.322	0.0659	-4.89	8.5
In-train time	-0.0554	0.00519	-10.68	1.0	-0.0379	0.00498	-7.62	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00765	0.00631	1.21	-0.1	0.00576	0.0058	0.99	-0.2
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.0261	0.0576	0.45	-0.5	0.153	0.0548	2.79	-4.0
Transfer time of 3 minutes BTM-train	-0.701	0.138	-5.09	12.7	-0.332	0.133	-2.49	8.8
Transfer time of 5 minutes BTM-train	-0.271	0.125	-2.17	4.9	-0.293	0.112	-2.62	7.7
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.538	0.116	-4.65	9.7	-0.369	0.11	-3.35	9.7
Transfer time of 15 minutes BTM-train	-0.725	0.115	-6.30	13.1	-0.644	0.111	-5.79	17.0
Transfer time of 3 minutes train-train	-0.0533	0.233	-0.23	1.0	-0.1	0.224	-0.45	2.6
Transfer time of 5 minutes train-train	-0.0268	0.228	-0.12	0.5	-0.0219	0.217	-0.10	0.6
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.125	0.221	-0.57	2.3	-0.0198	0.211	-0.09	0.5
Transfer time of 15 minutes train-train	-0.765	0.22	-3.47	13.8	-0.829	0.204	-4.07	21.9
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.0987	0.136	-0.73	1.8	-0.102	0.132	-0.77	2.7
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.361	0.146	2.47	-6.5	0.107	0.169	0.64	-2.8
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.349	0.149	2.34	-6.3	0.148	0.174	0.85	-3.9
Sigma BTM-train	0.0501	0.36	-0.14		0.00315	0.205	-0.02	
Sigma train-train	1.02	0.098	10.45		0.899	0.102	8.83	
Scale parameter in-train time RP trip < 70 minutes	1.000	fixed			-			
Scale parameter in-train time RP trip > 70 minutes	0.539	0.048	-9.62		-			
Null log-likelihood	-2681.79				-2231.93			
Final log-likelihood	-2136.11				-1849.30			
Adjusted ρ^2	0.192				0.158			

Appendix E3: General model by mode

Parameter	Bus total				Tram total				Metro total			
	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	-0.162	0.171	-0.95	3.1	0.117	0.254	0.46	-2.0	-0.0697	0.306	-0.23	0.9
ASC train-train	0	fixed			0	fixed			0	fixed		
Access time by bus	-0.0567	0.00734	-7.73	1.1								
Egress time by bus	-0.0787	0.00749	-10.51	1.5								
Access time by tram/metro					-0.0446	0.013	-3.43	0.8	-0.066	0.016	-4.11	0.9
Egress time by tram/metro					-0.0567	0.0114	-4.96	1.0	-0.0661	0.0193	-3.43	0.9
Costs, someone else pays, income < €2000	-0.323	0.0338	-9.56	6.1	-0.455	0.102	-4.45	7.7	-0.938	0.159	-5.90	12.1
Costs, someone else pays, income €2000 - €3000	-0.267	0.0669	-3.99	5.0	0.0685	0.129	0.53	-1.2	0.0466	0.133	0.35	-0.6
Costs, someone else pays, income €3000 - €6000	-0.147	0.0247	-5.94	2.8	-0.139	0.0459	-3.01	2.3	-0.241	0.0485	-4.96	3.1
Costs, someone else pays, income > €6000	-0.0474	0.0594	-0.80	0.9	-0.0353	0.0469	-0.75	0.6	-0.439	0.237	-1.85	5.7
Costs, traveler pays, income < €2000	-0.588	0.0357	-16.47	11.1	-0.607	0.0608	-9.98	10.2	-0.708	0.0803	-8.81	9.1
Costs, traveler pays, income €2000 - €3000	-0.541	0.0447	-12.11	10.2	-0.38	0.0588	-6.46	6.4	-0.48	0.0686	-6.99	6.2
Costs, traveler pays, income €3000 - €6000	-0.287	0.0229	-12.53	5.4	-0.414	0.0365	-11.32	7.0	-0.598	0.0575	-10.39	7.7
Costs, traveler pays, income > €6000	-0.274	0.0849	-3.23	5.2	-0.108	0.0641	-1.69	1.8	-0.188	0.155	-1.21	2.4
Headway connecting mode 15 minutes	0	fixed			0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.285	0.0479	-5.94	5.4	-0.254	0.0773	-3.29	4.3	-0.439	0.0984	-4.46	5.7
Headway connecting mode 30 minutes	-0.436	0.0507	-8.60	8.2	-0.685	0.0832	-8.23	11.6	-0.937	0.106	-8.85	12.1
In-train time	-0.0531	0.00387	-13.74	1.0	-0.0593	0.00642	-9.24	1.0	-0.0774	0.00844	-9.18	1.0
Piecewise linear parameter for train trips > 90 minutes	0.016	0.00462	3.47	-0.3	-0.0008	0.00809	-0.09	0.0	0.00372	0.0113	0.33	0.0
Transfer station medium/large	0	fixed			0	fixed			0	fixed		
Transfer station very large	0.0046	0.0416	0.11	-0.1	0.141	0.0669	2.11	-2.4	0.11	0.0857	1.29	-1.4
Transfer time of 3 minutes BTM-train	-0.518	0.113	-4.58	9.8	-0.669	0.169	-3.97	11.3	-0.131	0.216	-0.60	1.7
Transfer time of 5 minutes BTM-train	-0.495	0.103	-4.82	9.3	-0.184	0.153	-1.21	3.1	-0.109	0.21	-0.52	1.4
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.717	0.0839	-8.55	13.5	-0.43	0.132	-3.25	7.3	-0.741	0.168	-4.42	9.6
Transfer time of 15 minutes BTM-train	-1.01	0.0835	-12.07	19.0	-0.615	0.131	-4.71	10.4	-1.14	0.17	-6.67	14.7
Transfer time of 3 minutes train-train	-0.31	0.181	-1.72	5.8	0.0787	0.264	0.30	-1.3	0.09	0.342	0.26	-1.2
Transfer time of 5 minutes train-train	-0.221	0.172	-1.28	4.2	-0.0904	0.257	-0.35	1.5	-0.11	0.342	-0.32	1.4
Transfer time of 8 minutes train-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.453	0.162	-2.79	8.5	0.0218	0.242	0.09	-0.4	-0.593	0.309	-1.92	7.7
Transfer time of 15 minutes train-train	-1.2	0.162	-7.43	22.6	-0.987	0.249	-3.97	16.6	-1.14	0.309	-3.69	14.7
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.427	0.11	-3.89	8.0	-0.104	0.162	-0.64	1.8	-0.178	0.222	-0.80	2.3
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.297	0.106	2.80	-5.6	0.697	0.162	4.31	-11.8	0.476	0.208	2.28	-6.1
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.263	0.103	2.56	-5.0	0.512	0.163	3.15	-8.6	0.408	0.213	1.92	-5.3
Sigma BTM-train	0.00259	0.123	-0.02		0.223	0.198	-1.13		0.0371	0.243	0.15	
Sigma train-train	0.989	0.0723	13.68		0.777	0.107	7.27		1.03	0.149	6.91	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1.000	fixed			1.000	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.714	0.047	-6.14		0.653	0.063	-5.49		0.615	0.078	-4.96	
Null log-likelihood	-4847.18				-2138.36				-1364.11			
Final log-likelihood	-3930.46				-1770.18				-968.90			
Adjusted ρ^2	0.183				0.158				0.267			

Appendix E4: General model by trip stage

Parameter	Access total Value	Access total Std error	Access total t-test	Access total GTT	Egress total Value	Egress total Std error	Egress total t-test	Egress total GTT
ASC BTM-Train	-0.362	0.165	-2.19	7.3	-0.183	0.168	-1.09	3.1
ASC train-train	0	fixed			0	fixed		
Access time by bus	-0.0508	0.0066	-7.70	1.0				
Egress time by bus					-0.0871	0.00758	-11.48	1.5
Access time by tram/metro	-0.0331	0.00897	-3.69	0.7				
Egress time by tram/metro					-0.0546	0.00933	-5.85	0.9
Costs, someone else pays, income < €2000	-0.346	0.0307	-11.29	7.0	-0.382	0.0265	-14.42	6.4
Costs, someone else pays, income €2000 - €3000	-0.129	0.054	-2.40	2.6	-0.225	0.0703	-3.20	3.8
Costs, someone else pays, income €3000 - €6000	-0.192	0.0237	-8.13	3.9	-0.164	0.0255	-6.41	2.8
Costs, someone else pays, income > €6000	-0.138	0.0747	-1.85	2.8	-0.039	0.0352	-1.11	0.7
Costs, traveler pays, income < €2000	-0.59	0.0428	-13.78	12.0	-0.708	0.0456	-15.52	11.9
Costs, traveler pays, income €2000 - €3000	-0.428	0.0476	-8.98	8.7	-0.497	0.0552	-9.01	8.4
Costs, traveler pays, income €3000 - €6000	-0.233	0.0261	-8.94	4.7	-0.412	0.0309	-13.30	6.9
Costs, traveler pays, income > €6000	-0.0733	0.0485	-1.51	1.5	-0.243	0.0959	-2.53	4.1
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.274	0.05	-5.48	5.6	-0.343	0.051	-6.73	5.8
Headway connecting mode 30 minutes	-0.613	0.0524	-11.71	12.4	-0.575	0.0539	-10.67	9.7
In-train time	-0.0493	0.00406	-12.14	1.0	-0.0594	0.00419	-14.19	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00551	0.00532	1.04	-0.1	-0.0034	0.00571	-0.60	0.1
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.0457	0.0434	1.05	-0.9	0.045	0.0439	1.02	-0.8
Transfer time of 3 minutes BTM-train	-0.453	0.125	-3.64	9.2	-0.423	0.136	-3.11	7.1
Transfer time of 5 minutes BTM-train	-0.496	0.12	-4.14	10.1	-0.268	0.124	-2.16	4.5
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.729	0.0868	-8.40	14.8	-0.664	0.0875	-7.60	11.2
Transfer time of 15 minutes BTM-train	-0.938	0.0855	-10.98	19.0	-1.12	0.0887	-12.68	18.9
Transfer time of 3 minutes train-train	-0.362	0.185	-1.96	7.3	-0.603	0.198	-3.04	10.2
Transfer time of 5 minutes train-train	-0.453	0.182	-2.49	9.2	-0.226	0.188	-1.20	3.8
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.454	0.164	-2.78	9.2	-0.711	0.167	-4.27	12.0
Transfer time of 15 minutes train-train	-1.32	0.164	-8.03	26.8	-1.15	0.166	-6.94	19.4
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.455	0.122	-3.72	9.2	-0.353	0.135	-2.62	5.9
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.3	0.116	2.58	-6.1	0.555	0.128	4.32	-9.3
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.374	0.116	3.21	-7.6	0.325	0.121	2.69	-5.5
Sigma BTM-train	0.00647	0.114	0.06		0.00735	0.12	-0.06	
Sigma train-train	0.661	0.0785	8.41		0.941	0.077	12.22	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.664	0.0606	-5.55		0.620	0.054	-6.99	
Null log-likelihood	-4039.54				-4291.71			
Final log-likelihood	-3338.082				-3302.48			
Adjusted ρ^2	0.187				0.224			

Appendix E5: General model by frequency

Parameter	Frequency high total				Frequency medium total				Frequency low total			
	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	-0.162	0.169	-0.96	2.4	-0.12	0.256	-0.47	2.6	0.438	0.276	1.59	-9.1
ASC train-train	0	fixed			0	fixed			0	fixed		
Access time by bus	-0.0758	0.00875	-8.67	1.1	-0.0654	0.0131	-4.98	1.4	-0.0594	0.0122	-4.87	1.2
Egress time by bus	-0.11	0.00892	-12.28	1.6	-0.0766	0.0142	-5.41	1.6	-0.0607	0.0141	-4.31	1.3
Access time by tram/metro	-0.0587	0.0131	-4.48	0.9	-0.0385	0.0156	-2.46	0.8	-0.0308	0.0139	-2.22	0.6
Egress time by tram/metro	-0.0583	0.0106	-5.49	0.8	-0.0364	0.014	-2.60	0.8	-0.0648	0.0161	-4.03	1.4
Costs, someone else pays, income < €2000	-0.443	0.0356	-12.45	6.4	-0.241	0.0731	-3.30	5.2	0		0.00	0.0
Costs, someone else pays, income €2000 - €3000	-0.15	0.0618	-2.43	2.2	-0.106	0.108	-0.98	2.3	-1.08	0.263	-4.11	22.5
Costs, someone else pays, income €3000 - €6000	-0.152	0.0224	-6.77	2.2	-0.336	0.0938	-3.58	7.2	-0.218	0.053	-4.10	4.6
Costs, someone else pays, income > €6000	-0.0609	0.0371	-1.64	0.9								
Costs, traveler pays, income < €2000	-0.627	0.0476	-13.19	9.1	-0.47	0.0489	-9.60	10.1	-0.62	0.0467	-13.29	12.9
Costs, traveler pays, income €2000 - €3000	-0.407	0.0524	-7.77	5.9	-0.422	0.0453	-9.32	9.1	-0.498	0.0588	-8.47	10.4
Costs, traveler pays, income €3000 - €6000	-0.365	0.0286	-12.76	5.3	-0.317	0.0315	-10.06	6.8	-0.361	0.0318	-11.33	7.5
Costs, traveler pays, income > €6000	-0.147	0.0545	-2.70	2.1	-0.346	0.204	-1.70	7.4	-0.226	0.0997	-2.27	4.7
Headway connecting mode 15 minutes	0	fixed			0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.4	0.0523	-7.64	5.8	-0.282	0.0701	-4.03	6.1	-0.115	0.078	-1.47	2.4
Headway connecting mode 30 minutes	-0.715	0.055	-13.00	10.4	-0.448	0.0746	-6.00	9.6	-0.338	0.0826	-4.09	7.1
In-train time	-0.0687	0.00444	-15.47	1.0	-0.0465	0.00556	-8.36	1.0	-0.0479	0.00618	-7.75	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00372	0.00593	0.63	-0.1	0.00655	0.00665	0.98	-0.1	0.0147	0.00695	2.12	-0.3
Transfer station medium/large	0	fixed			0	fixed			0	fixed		
Transfer station very large	0.0684	0.0446	1.54	-1.0	0.0294	0.0612	0.48	-0.6	0.0797	0.069	1.16	-1.7
Transfer time of 3 minutes BTM-train	-0.0878	0.084	-1.05	1.3	-0.297	0.138	-2.15	6.4	-0.548	0.153	-3.58	11.4
Transfer time of 5 minutes BTM-train	-0.0312	0.0868	-0.36	0.5	-0.267	0.121	-2.21	5.7	-0.222	0.137	-1.63	4.6
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.81	0.0874	-9.26	11.8	-0.515	0.122	-4.21	11.1	-0.24	0.14	-1.72	5.0
Transfer time of 15 minutes BTM-train	-1.16	0.0875	-13.28	16.9	-0.62	0.123	-5.04	13.3	-0.564	0.139	-4.05	11.8
Transfer time of 3 minutes train-train	0.0597	0.17	0.35	-0.9	0.17	0.246	0.69	-3.7	0.145	0.268	0.54	-3.0
Transfer time of 5 minutes train-train	0.0162	0.168	0.10	-0.2	-0.184	0.237	-0.78	4.0	0.386	0.266	1.45	-8.1
Transfer time of 8 minutes train-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.538	0.166	-3.25	7.8	-0.471	0.237	-1.99	10.1	0.176	0.263	0.67	-3.7
Transfer time of 15 minutes train-train	-1.35	0.171	-7.90	19.7	-1.01	0.237	-4.28	21.7	-0.501	0.259	-1.93	10.5
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.387	0.124	-3.12	5.6	-0.275	0.144	-1.91	5.9	-0.105	0.16	-0.66	2.2
Sigma BTM-train	0.0374	0.18	0.21		0.00856	0.223	0.04		0.0151	0.205	-0.07	
Sigma train-train	0.935	0.0788	11.86		0.984	0.105	9.34		0.811	0.105	7.69	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1.000	fixed			1.000	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.716	0.061	-4.62		0.821	0.080	-2.24		0.705	0.074	-3.98	
Null log-likelihood	-4168.59				-2145.98				-2035.08			
Final log-likelihood	-3171.579				-1792.25				-1706.91			
Adjusted ρ^2	0.232				0.151				0.147			

Appendix E6: General model by separate stations

Parameter	Rotterdam Centraal total				Den Haag Centraal total			
	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	0.595	0.439	1.35	-12.5	0.123	0.608	0.20	-1.7
ASC train-train	0	fixed			0	fixed		
Access time by bus	-0.0879	0.0466	-1.88	1.8	-0.0963	0.0343	-2.81	1.3
Egress time by bus	0.106	0.177	0.60	-2.2	-0.142	0.0669	-2.12	1.9
Access time by tram/metro	-0.0696	0.0171	-4.06	1.5	-0.0536	0.0297	-1.80	0.7
Egress time by tram/metro	-0.0667	0.0203	-3.28	1.4	-0.0651	0.024	-2.71	0.9
Costs, someone else pays, income < €2000	-1.14	0.358	-3.20	23.9	-0.615	0.297	-2.07	8.4
Costs, someone else pays, income €2000 - €3000	-0.415	0.573	-0.72	8.7	0.117	0.179	0.66	-1.6
Costs, someone else pays, income €3000 - €6000	-0.223	0.0609	-3.66	4.7	-0.103	0.0571	-1.80	1.4
Costs, someone else pays, income > €6000					0.145	0.103	1.40	-2.0
Costs, traveler pays, income < €2000	-0.493	0.0869	-5.67	10.3	-1.32	0.197	-6.69	18.0
Costs, traveler pays, income €2000 - €3000	-0.305	0.0832	-3.67	6.4	-0.529	0.131	-4.03	7.2
Costs, traveler pays, income €3000 - €6000	-0.479	0.0707	-6.77	10.0	-0.208	0.0569	-3.66	2.8
Costs, traveler pays, income > €6000	-0.0425	0.16	-0.27	0.9	-0.268	0.177	-1.52	3.7
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.473	0.139	-3.40	9.9	-0.0786	0.164	-0.48	1.1
Headway connecting mode 30 minutes	-0.762	0.147	-5.19	16.0	-0.765	0.188	-4.07	10.4
In-train time	-0.0477	0.011	-4.33	1.0	-0.0734	0.0137	-5.38	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00646	0.0132	0.49	-0.1	0.00218	0.0176	0.12	0.0
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.184	0.12	1.54	-3.9	0.061	0.15	0.41	-0.8
Transfer time of 3 minutes BTM-train	-0.453	0.284	-1.59	9.5	-1.48	0.384	-3.85	20.2
Transfer time of 5 minutes BTM-train	-0.0337	0.265	-0.13	0.7	-0.241	0.333	-0.72	3.3
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.398	0.237	-1.68	8.3	-0.115	0.298	-0.39	1.6
Transfer time of 15 minutes BTM-train	-0.745	0.235	-3.17	15.6	-0.398	0.291	-1.37	5.4
Transfer time of 3 minutes train-train	0.35	0.474	0.74	-7.3	-1.09	0.583	-1.86	14.9
Transfer time of 5 minutes train-train	0.512	0.469	1.09	-10.7	-0.285	0.545	-0.52	3.9
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.46	0.451	-1.02	9.6	1.25	0.576	2.17	-17.0
Transfer time of 15 minutes train-train	-0.974	0.447	-2.18	20.4	-0.608	0.579	-1.05	8.3
Extra parameter applicable with transfer time of 3 minutes and age > 60	0.0954	0.278	0.34	-2.0	0.539	0.384	1.40	-7.3
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.0605	0.278	0.22	-1.3	1.17	0.384	3.05	-15.9
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.0436	0.295	0.15	-0.9	0.8	0.371	2.16	-10.9
Sigma BTM-train	0.0339	0.502	-0.07		0.474	0.222	2.14	
Sigma train-train	0.638	0.223	2.87		1.04	0.215	4.83	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.915	0.172	-0.49		0.441	0.106	-5.30	
Null log-likelihood	-550.36				-621.06			
Final log-likelihood	-421.246				-507.61			
Adjusted ρ^2	0.238				0.133			

Appendix E7: Access model by trip motive

Parameter	Workbusiness access Value	Std error	t-test	GTT	School/study access Value	Std error	t-test	GTT
ASC BTM-Train	-0.155	0.269	-0.58	2.5	-1.02	0.633	-1.61	22.2
ASC train-train	0	fixed			0	fixed		
Access time by bus	-0.0652	0.0124	-5.28	1.0	-0.0394	0.022	-1.83	0.9
Egress time by bus								
Access time by tram/metro	-0.0414	0.0159	-2.60	0.7	-0.0378	0.035	-1.10	0.8
Egress time by tram/metro								
Costs, someone else pays, income < €2000	-0.099	0.072	-1.38	1.6	-0.395	0.08	-4.93	8.6
Costs, someone else pays, income €2000 - €3000	-0.151	0.0654	-2.30	2.4	0	0.089	0.00	0.0
Costs, someone else pays, income €3000 - €6000	-0.151	0.0302	-5.00	2.4	-0.689	0.199	-3.47	15.0
Costs, someone else pays, income > €6000	-0.147	0.0881	-1.67	2.4				
Costs, traveler pays, income < €2000	-0.769	0.138	-5.57	12.3	-0.578	0.129	-4.47	12.6
Costs, traveler pays, income €2000 - €3000	-0.365	0.0655	-5.58	5.8				
Costs, traveler pays, income €3000 - €6000	-0.205	0.0361	-5.66	3.3	-0.336	0.23	-1.46	7.3
Costs, traveler pays, income > €6000	-0.079	0.0599	-1.32	1.3				
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.238	0.0833	-2.86	3.8	-0.365	0.184	-1.99	8.0
Headway connecting mode 30 minutes	-0.697	0.0868	-8.03	11.2	-0.709	0.191	-3.72	15.4
In-train time	-0.0625	0.0071	-8.87	1.0	-0.0459	0.014	-3.21	1.0
Piecewise linear parameter for train trips > 90 minutes	-0.00689	0.0107	-0.65	0.1	0.0232	0.019	1.25	-0.5
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.0215	0.0705	0.31	-0.3	0.0653	0.159	0.41	-1.4
Transfer time of 3 minutes BTM-train	-0.251	0.213	-1.18	4.0	-0.0087	0.744	-0.01	0.2
Transfer time of 5 minutes BTM-train	-0.396	0.222	-1.79	6.3	-0.911	0.536	-1.70	19.8
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.71	0.139	-5.12	11.4	-0.951	0.329	-2.89	20.7
Transfer time of 15 minutes BTM-train	-0.786	0.135	-5.83	12.6	-1.35	0.326	-4.13	29.4
Transfer time of 3 minutes train-train	0.325	0.312	1.04	-5.2	-1.02	0.873	-1.17	22.2
Transfer time of 5 minutes train-train	-0.101	0.307	-0.33	1.6	-1.35	0.748	-1.80	29.4
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.404	0.258	-1.57	6.5	-0.688	0.65	-1.06	15.0
Transfer time of 15 minutes train-train	-1.26	0.275	-4.59	20.2	-1.82	0.594	-3.07	39.7
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.391	0.188	-2.08	6.3	-2.84	0.99	-2.86	61.9
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.152	0.204	0.75	-2.4	-0.238	0.722	-0.33	5.2
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.282	0.214	1.32	-4.5	0.71	0.512	1.39	-15.5
Sigma BTM-train	0.0349	0.243	0.14		0.00306	0.551	0.01	
Sigma train-train	0.799	0.135	5.94		0.256	0.562	0.46	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			-			
Scale parameter in-train time RP trip > 70 minutes	1.490	0.417	1.16		-			
Null log-likelihood	-1384.91				-307.06			
Final log-likelihood	-1102.979				0.129			
Adjusted ρ^2	0.183				0.198			

Parameter	Social access Value	Std error	t-test	GTT	Recreational/other access Value	Std error	t-test	GTT
ASC BTM-Train	0.291	0.284	1.02	-6.1	0.36	0.308	1.17	-10.6
ASC train-train	0	fixed			0	fixed		
Access time by bus	-0.0506	0.0119	-4.25	1.1	-0.053	0.0128	-4.15	1.6
Egress time by bus								
Access time by tram/metro	-0.0231	0.0137	-1.69	0.5	-0.0352	0.0133	-2.64	1.0
Egress time by tram/metro								
Costs, someone else pays, income < €2000	-0.727	0.113	-6.45	15.3	-1.02	0.284	-3.60	30.0
Costs, someone else pays, income €2000 - €3000								
Costs, someone else pays, income €3000 - €6000	-0.137	0.0761	-1.80	2.9	-0.203	0.0979	-2.07	6.0
Costs, someone else pays, income > €6000								
Costs, traveler pays, income < €2000	-0.474	0.0458	-10.34	10.0	-0.477	0.0569	-8.38	14.0
Costs, traveler pays, income €2000 - €3000	-0.344	0.0664	-5.18	7.2	-0.375	0.0554	-6.77	11.0
Costs, traveler pays, income €3000 - €6000	-0.29	0.0383	-7.59	6.1	-0.342	0.0401	-8.53	10.1
Costs, traveler pays, income > €6000	-0.0764	0.125	-0.61	1.6	-0.79	0.214	-3.69	23.2
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.21	0.0841	-2.49	4.4	-0.189	0.0853	-2.21	5.6
Headway connecting mode 30 minutes	-0.274	0.0894	-3.06	5.8	-0.292	0.09	-3.24	8.6
In-train time	-0.0475	0.00743	-6.40	1.0	-0.034	0.00667	-5.10	1.0
Piecewise linear parameter for train trips > 90 minutes	0.0174	0.00784	2.22	-0.4	0.00105	0.00798	0.13	0.0
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	-0.0245	0.074	-0.33	0.5	0.103	0.0761	1.35	-3.0
Transfer time of 3 minutes BTM-train	-0.725	0.172	-4.21	15.3	-0.481	0.181	-2.66	14.1
Transfer time of 5 minutes BTM-train	-0.393	0.163	-2.42	8.3	-0.433	0.155	-2.78	12.7
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.457	0.148	-3.08	9.6	-0.514	0.154	-3.34	15.1
Transfer time of 15 minutes BTM-train	-0.627	0.146	-4.29	13.2	-0.668	0.157	-4.27	19.6
Transfer time of 3 minutes train-train	0.126	0.281	0.45	-2.7	-0.17	0.305	-0.56	5.0
Transfer time of 5 minutes train-train	0.109	0.276	0.39	-2.3	-0.146	0.299	-0.49	4.3
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	0.151	0.271	0.56	-3.2	0.00031	0.3	0.00	0.0
Transfer time of 15 minutes train-train	-0.457	0.274	-1.67	9.6	-0.751	0.288	-2.61	22.1
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.0765	0.18	-0.42	1.6	0.0962	0.178	0.54	-2.8
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.318	0.188	1.69	-6.7	-0.25	0.256	-0.98	7.4
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.561	0.194	2.89	-11.8	-0.309	0.285	-1.08	9.1
Sigma BTM-train	0.0137	0.25	0.05		0.0107	0.194	0.06	
Sigma train-train	0.801	0.142	5.63		0.906	0.147	6.16	
Scale parameter in-train time RP trip < 70 minutes	1.000	fixed			-			
Scale parameter in-train time RP trip > 70 minutes	1.080	0.290	0.27		-			
Null log-likelihood	-1214.39				-1140.92			
Final log-likelihood	-975.51				-948.91			
Adjusted ρ^2	0.173				0.143			

Appendix E8: Access model by mode

Parameter	Bus access				Tram access				Metro access			
	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	-0.144	0.215	-0.67	3.1	0.103	0.492	0.21	-1.7	0.407	0.519	0.78	-3.9
ASC train-train	0	fixed			0	fixed			0	fixed		
Access time by bus	-0.051	0.00839	-6.07	1.1								
Egress time by bus												
Access time by tram/metro					-0.0278	0.0217	-1.28	0.5	-0.1	0.0222	-4.51	1.0
Egress time by tram/metro												
Costs, someone else pays, income < €2000	-0.301	0.0465	-6.47	6.4	-1.12	0.267	-4.18	18.6	-1.71	0.447	-3.83	16.4
Costs, someone else pays, income €2000 - €3000	-0.279	0.088	-3.17	5.9	0.075	0.136	0.55	-1.2				
Costs, someone else pays, income €3000 - €6000	-0.16	0.0303	-5.26	3.4	-0.0693	0.0858	-0.81	1.2	-0.248	0.0964	-2.57	2.4
Costs, someone else pays, income > €6000	-0.00319	0.107	-0.03	0.1	-0.398	0.157	-2.53	6.6				
Costs, traveler pays, income < €2000	-0.569	0.0464	-12.25	12.1	-0.893	0.122	-7.34	14.9	-0.922	0.134	-6.89	8.9
Costs, traveler pays, income €2000 - €3000	-0.515	0.0568	-9.07	10.9	-0.364	0.136	-2.68	6.1	-0.422	0.102	-4.15	4.1
Costs, traveler pays, income €3000 - €6000	-0.289	0.0291	-9.92	6.1	-0.184	0.0625	-2.94	3.1	-0.734	0.116	-6.34	7.1
Costs, traveler pays, income > €6000	-0.365	0.116	-3.15	7.7	-0.0032	0.09	-0.04	0.1	0.0705	0.306	0.23	-0.7
Headway connecting mode 15 minutes	0	fixed			0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.251	0.0611	-4.10	5.3	-0.177	0.139	-1.27	2.9	-0.413	0.188	-2.20	4.0
Headway connecting mode 30 minutes	-0.435	0.0642	-6.77	9.2	-0.769	0.149	-5.17	12.8	-0.982	0.2	-4.92	9.4
In-train time	-0.0471	0.00494	-9.54	1.0	-0.0601	0.0121	-4.98	1.0	-0.104	0.0162	-6.43	1.0
Piecewise linear parameter for train trips > 90 minutes	0.0129	0.00584	2.20	-0.3	-0.0105	0.0158	-0.66	0.2	-0.0031	0.0217	-0.14	0.0
Transfer station medium/large	0	fixed			0	fixed			0	fixed		
Transfer station very large	-0.0142	0.0529	-0.27	0.3	0.132	0.12	1.10	-2.2	0.111	0.167	0.66	-1.1
Transfer time of 3 minutes BTM-train	-0.604	0.141	-4.28	12.8	-0.543	0.27	-2.01	9.0	-0.828	0.389	-2.13	8.0
Transfer time of 5 minutes BTM-train	-0.594	0.13	-4.58	12.6	-0.175	0.272	-0.64	2.9	-0.294	0.374	-0.78	2.8
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.667	0.107	-6.21	14.2	-0.728	0.239	-3.05	12.1	-0.873	0.309	-2.83	8.4
Transfer time of 15 minutes BTM-train	-0.83	0.106	-7.85	17.6	-0.671	0.233	-2.88	11.2	-1.43	0.309	-4.61	13.8
Transfer time of 3 minutes train-train	-0.238	0.224	-1.06	5.1	0.375	0.468	0.80	-6.2	-0.0118	0.601	-0.02	0.1
Transfer time of 5 minutes train-train	-0.377	0.216	-1.74	8.0	0.278	0.465	0.60	-4.6	-0.328	0.601	-0.55	3.2
Transfer time of 8 minutes train-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.395	0.205	-1.93	8.4	0.659	0.443	1.49	-11.0	-0.34	0.588	-0.58	3.3
Transfer time of 15 minutes train-train	-1.14	0.204	-5.58	24.2	-0.905	0.451	-2.01	15.1	-1.27	0.62	-2.06	12.2
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.317	0.134	-2.37	6.7	0.0255	0.343	0.07	-0.4	0.435	0.427	1.02	-4.2
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.272	0.131	2.08	-5.8	0.28	0.277	1.01	-4.7	1.16	0.381	3.04	-11.2
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.382	0.131	2.92	-8.1	0.23	0.29	0.79	-3.8	0.869	0.396	2.20	-8.4
Sigma BTM-train	0.0122	0.145	0.08		0.117	0.601	0.20		0.00287	0.267	-0.01	
Sigma train-train	0.831	0.0924	8.99		1.02	0.195	5.23		0.418	0.281	1.49	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1.000	fixed			1.000	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.762	0.067	-3.54		0.584	0.108	-3.85		0.459	0.087	-6.21	
Null log-likelihood	-2806.55				-717.41				-523.33			
Final log-likelihood	-2332.717				-572.78				-341.72			
Adjusted ρ^2	0.158				0.161				0.292			

Appendix E9: Access model by frequency

Parameter	Frequency high access				Frequency medium access				Frequency low access			
	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	-0.255	0.237	-1.08	4.1	0.0194	0.401	0.05	-0.4	0.668	0.367	1.82	-15.8
ASC train-train	0	fixed			0	fixed			0	fixed		
Access time by bus	-0.0598	0.0102	-5.84	1.0	-0.0693	0.0165	-4.19	1.6	-0.0556	0.0144	-3.87	1.3
Egress time by bus												
Access time by tram/metro	-0.0422	0.0137	-3.08	0.7	-0.0423	0.0181	-2.34	1.0	-0.0281	0.0155	-1.81	0.7
Egress time by tram/metro												
Costs, someone else pays, income < €2000	-0.475	0.0562	-8.46	7.6	-0.231	0.0781	-2.96	5.3				
Costs, someone else pays, income €2000 - €3000	-0.17	0.0779	-2.18	2.7	0.13	0.141	0.92	-3.0				
Costs, someone else pays, income €3000 - €6000	-0.137	0.0312	-4.39	2.2	-0.259	0.124	-2.09	5.9	-0.316	0.0737	-4.29	7.5
Costs, someone else pays, income > €6000	-0.155	0.0871	-1.78	2.5								
Costs, traveler pays, income < €2000	-0.624	0.0666	-9.37	10.0	-0.589	0.0769	-7.66	13.4	-0.587	0.0616	-9.52	13.9
Costs, traveler pays, income €2000 - €3000	-0.31	0.0716	-4.33	5.0	-0.459	0.0722	-6.37	10.5	-0.447	0.069	-6.48	10.6
Costs, traveler pays, income €3000 - €6000	-0.264	0.0376	-7.01	4.2	-0.305	0.0444	-6.86	6.9	-0.348	0.0484	-7.19	8.2
Costs, traveler pays, income > €6000	-0.133	0.059	-2.26	2.1	-0.332	0.22	-1.51	7.6	-0.0344	0.154	-0.22	0.8
Headway connecting mode 15 minutes	0	fixed			0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.355	0.0747	-4.75	5.7	-0.223	0.102	-2.19	5.1	-0.129	0.105	-1.23	3.1
Headway connecting mode 30 minutes	-0.749	0.0781	-9.59	12.0	-0.32	0.108	-2.97	7.3	-0.288	0.11	-2.62	6.8
In-train time	-0.0623	0.00624	-9.98	1.0	-0.0439	0.00828	-5.30	1.0	-0.0422	0.00817	-5.17	1.0
Piecewise linear parameter for train trips > 90 minutes	0.000816	0.00841	0.10	0.0	0.00599	0.00959	0.62	-0.1	0.00717	0.00927	0.77	-0.2
Transfer station medium/large	0	fixed			0	fixed			0	fixed		
Transfer station very large	0.0635	0.0641	0.99	-1.0	0.0391	0.0883	0.44	-0.9	-0.0362	0.092	-0.39	0.9
Transfer time of 3 minutes BTM-train	-0.277	0.122	-2.27	4.4	-0.445	0.199	-2.24	10.1	-0.639	0.202	-3.16	15.1
Transfer time of 5 minutes BTM-train	-0.0696	0.126	-0.55	1.1	-0.432	0.18	-2.40	9.8	-0.42	0.186	-2.26	10.0
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.802	0.126	-6.39	12.9	-0.598	0.178	-3.36	13.6	-0.352	0.19	-1.85	8.3
Transfer time of 15 minutes BTM-train	-1.02	0.123	-8.28	16.4	-0.622	0.18	-3.46	14.2	-0.553	0.188	-2.94	13.1
Transfer time of 3 minutes train-train	0.149	0.237	0.63	-2.4	0.0509	0.351	0.15	-1.2	0.119	0.354	0.34	-2.8
Transfer time of 5 minutes train-train	0.00255	0.235	0.01	0.0	-0.302	0.354	-0.85	6.9	0.275	0.353	0.78	-6.5
Transfer time of 8 minutes train-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.367	0.234	-1.57	5.9	-0.4	0.353	-1.13	9.1	0.301	0.352	0.86	-7.1
Transfer time of 15 minutes train-train	-1.26	0.241	-5.21	20.2	-1.35	0.34	-3.96	30.8	-0.236	0.345	-0.69	5.6
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.326	0.176	-1.85	5.2	-0.0687	0.206	-0.33	1.6	-0.0013	0.213	-0.01	0.0
Sigma BTM-train	0.0044	0.2	0.02		0.0324	0.296	0.11		0.00832	0.176	0.05	
Sigma train-train	0.688	0.117	5.89		0.952	0.155	6.16		0.827	0.145	5.68	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1.000	fixed			1.000	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.705	0.101	-2.92		0.832	0.130	-1.29		0.723	0.118	-2.34	
Null log-likelihood	-1917.94				-1027.94				-1101.41			
Final log-likelihood	-1500.394				-852.48				-932.49			
Adjusted ρ^2	0.204				0.144				0.129			

Appendix E10: Access model by station

Parameter	Rotterdam Centraal access				Den Haag Centraal access			
	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	0.287	0.808	0.35	-3.9	0.51	0.919	0.55	-8.7
ASC train-train	0	fixed			0	fixed		
Access time by bus	-0.111	0.0623	-1.78	1.5	-0.0969	0.044	-2.20	1.6
Egress time by bus								
Access time by tram/metro	-0.0833	0.031	-2.69	1.1	-0.0504	0.0404	-1.25	0.9
Egress time by tram/metro								
Costs, someone else pays, income < €2000					-0.533	0.309	-1.72	9.1
Costs, someone else pays, income €2000 - €3000					0.195	0.196	0.99	-3.3
Costs, someone else pays, income €3000 - €6000	-0.361	0.142	-2.55	4.9	-0.0276	0.109	-0.25	0.5
Costs, someone else pays, income > €6000					0	0.157	0.00	0.0
Costs, traveler pays, income < €2000	-0.942	0.189	-4.97	12.8	-2.46	0.467	-5.28	41.8
Costs, traveler pays, income €2000 - €3000	-0.928	0.256	-3.63	12.6	-0.404	0.234	-1.73	6.9
Costs, traveler pays, income €3000 - €6000	-0.244	0.122	-2.00	3.3	-0.123	0.0722	-1.70	2.1
Costs, traveler pays, income > €6000	-0.0936	0.36	-0.26	1.3	-0.347	0.19	-1.83	5.9
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.797	0.28	-2.84	10.8	-0.203	0.23	-0.88	3.5
Headway connecting mode 30 minutes	-1.15	0.28	-4.09	15.6	-0.642	0.25	-2.57	10.9
In-train time	-0.0737	0.0212	-3.48	1.0	-0.0588	0.0183	-3.22	1.0
Piecewise linear parameter for train trips > 90 minutes	-0.0528	0.0359	-1.47	0.7	-0.0487	0.0267	-1.82	0.8
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.32	0.229	1.40	-4.3	-0.068	0.201	-0.34	1.2
Transfer time of 3 minutes BTM-train	0.0561	0.497	0.11	-0.8	-2.25	0.547	-4.12	38.3
Transfer time of 5 minutes BTM-train	0.37	0.486	0.76	-5.0	-0.25	0.425	-0.59	4.3
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.586	0.46	-1.28	8.0	-0.441	0.398	-1.11	7.5
Transfer time of 15 minutes BTM-train	-0.924	0.451	-2.05	12.5	-0.649	0.389	-1.67	11.0
Transfer time of 3 minutes train-train	0.593	0.949	0.63	-8.0	-1.8	0.806	-2.24	30.6
Transfer time of 5 minutes train-train	0.911	0.87	1.05	-12.4	-0.531	0.75	-0.71	9.0
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.61	0.805	-0.76	8.3	1.3	0.786	1.66	-22.1
Transfer time of 15 minutes train-train	-1.33	0.827	-1.61	18.0	-1.32	0.825	-1.60	22.4
Extra parameter applicable with transfer time of 3 minutes and age > 60	0.349	0.664	0.53	-4.7	2.04	0.558	3.66	-34.7
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	-0.404	0.579	-0.70	5.5	1.61	0.544	2.95	-27.4
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	-0.604	0.596	-1.01	8.2	0.524	0.512	1.02	-8.9
Sigma BTM-train	0.00552	0.57	0.01		0.438	0.385	1.14	
Sigma train-train	0.331	0.454	0.73		1.56	0.392	3.97	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.364	0.113	-5.62		0.573	0.189	-2.26	
Null log-likelihood	-293.20				-316.08			
Final log-likelihood	-209.578				-227.86			
Adjusted ρ^2	0.286				0.187			

Appendix E11: Egress model by tripmotive

Parameter	Work/business egress Value	Std error	t-test	GTT	School/study egress Value	Std error	t-test	GTT
ASC BTM-Train	-0.27	0.289	-0.93	3.0	-0.3	0.547	-0.55	7.7
ASC train-train	0	fixed			0	fixed		
Access time by bus Egress time by bus	-0.142	0.0154	-9.21	1.6	0.0506	0.021	-2.36	1.3
Access time by tram/metro Egress time by tram/metro	-0.0779	0.0171	-4.55	0.9	0.0527	0.032	-1.67	1.3
Costs, someone else pays, income < €2000	-0.368	0.117	-3.16	4.1	-0.395	0.061	-6.50	10.1
Costs, someone else pays, income €2000 - €3000	-0.229	0.0942	-2.42	2.5	-0.284	0.295	-0.96	7.2
Costs, someone else pays, income €3000 - €6000	-0.155	0.0324	-4.79	1.7	-0.585	0.254	-2.31	14.9
Costs, someone else pays, income > €6000	-0.05	0.0431	-1.16	0.6				
Costs, traveler pays, income < €2000	-0.613	0.135	-4.55	6.8	-0.86	0.142	-6.04	21.9
Costs, traveler pays, income €2000 - €3000	-0.465	0.0877	-5.30	5.2	-0.748	0.46	-1.62	19.1
Costs, traveler pays, income €3000 - €6000	-0.387	0.0476	-8.14	4.3	-0.814	0.357	-2.28	20.8
Costs, traveler pays, income > €6000	-0.251	0.126	-1.99	2.8				
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.502	0.0918	-5.47	5.6	-0.19	0.172	-1.11	4.8
Headway connecting mode 30 minutes	-0.863	0.0972	-8.88	9.6	-0.319	0.182	-1.75	8.1
In-train time	-0.0899	0.0084	-10.67	1.0	-0.0392	0.013	-2.97	1.0
Piecewise linear parameter for train trips > 90 minutes	0.0193	0.0131	1.47	-0.2	-0.0453	0.019	-2.38	1.2
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.0665	0.0766	0.87	-0.7	-0.0186	0.148	-0.13	0.5
Transfer time of 3 minutes BTM-train	0.0622	0.329	0.19	-0.7	-0.387	0.473	-0.82	9.9
Transfer time of 5 minutes BTM-train	0.0349	0.298	0.12	-0.4	-0.35	0.421	-0.83	8.9
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.727	0.147	-4.93	8.1	-0.444	0.303	-1.47	11.3
Transfer time of 15 minutes BTM-train	-1.31	0.152	-8.66	14.6	-0.979	0.302	-3.24	25.0
Transfer time of 3 minutes train-train	0.0739	0.416	0.18	-0.8	-1.47	0.69	-2.14	37.5
Transfer time of 5 minutes train-train	-0.0946	0.385	-0.25	1.1	-0.579	0.624	-0.93	14.8
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.883	0.284	-3.11	9.8	-1.13	0.582	-1.93	28.8
Transfer time of 15 minutes train-train	-1.44	0.297	-4.85	16.0	-0.895	0.544	-1.64	22.8
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.378	0.228	-1.66	4.2	-0.824	0.944	-0.87	21.0
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.128	0.319	0.40	-1.4	0.666	0.475	1.40	-17.0
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.111	0.294	0.38	-1.2	0.536	0.405	1.33	-13.7
Sigma BTM-train	0.0457	0.466	-0.10		0.0112	0.217	0.05	
Sigma train-train	0.986	0.143	6.90		0.776	0.279	2.78	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			-			
Scale parameter in-train time RP trip > 70 minutes	0.965	0.284	-0.12		-			
Null log-likelihood	-1391.15				-352.81			
Final log-likelihood	-1012.901				-254.9			
Adjusted ρ^2	0.251				0.195			

Parameter	Social egress Value	Std error	t-test	GTT	Recreational/other egress Value	Std error	t-test	GTT
ASC BTM-Train	0.104	0.311	0.33	-1.9	0.19	0.305	0.62	-4.1
ASC train-train	0	fixed			0	fixed		
Access time by bus								
Egress time by bus	-0.0938	0.0142	-6.60	1.7	-0.074	0.0139	-5.32	1.6
Access time by tram/metro								
Egress time by tram/metro	-0.0403	0.0156	-2.58	0.7	-0.0778	0.0164	-4.75	1.7
Costs, someone else pays, income < €2000	-0.572	0.109	-5.24	10.3	0.0214	0.134	0.16	-0.5
Costs, someone else pays, income €2000 - €3000					-0.604	0.306	-1.97	13.2
Costs, someone else pays, income €3000 - €6000	-0.369	0.128	-2.89	6.6	-0.275	0.237	-1.16	6.0
Costs, someone else pays, income > €6000								
Costs, traveler pays, income < €2000	-0.486	0.0541	-9.00	8.7	-0.618	0.0736	-8.40	13.5
Costs, traveler pays, income €2000 - €3000	-0.477	0.0634	-7.51	8.5	-0.501	0.084	-5.97	10.9
Costs, traveler pays, income €3000 - €6000	-0.454	0.0466	-9.74	8.1	-0.327	0.0335	-9.74	7.1
Costs, traveler pays, income > €6000	-0.402	0.175	-2.30	7.2				
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.316	0.0893	-3.54	5.7	-0.155	0.0927	-1.67	3.4
Headway connecting mode 30 minutes	-0.523	0.0959	-5.45	9.4	-0.391	0.1	-3.90	8.5
In-train time	-0.0558	0.00685	-8.14	1.0	-0.0459	0.00768	-5.97	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00908	0.0086	1.06	-0.2	0.0133	0.00877	1.51	-0.3
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	0.0648	0.0782	0.83	-1.2	0.239	0.0813	2.94	-5.2
Transfer time of 3 minutes BTM-train	-0.464	0.192	-2.41	8.3	-0.2	0.161	-1.24	4.4
Transfer time of 5 minutes BTM-train	-0.212	0.168	-1.26	3.8	-0.119	0.163	-0.73	2.6
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.57	0.158	-3.62	10.2	-0.193	0.155	-1.24	4.2
Transfer time of 15 minutes BTM-train	-0.771	0.158	-4.87	13.8	-0.621	0.154	-4.03	13.5
Transfer time of 3 minutes train-train	0.106	0.316	0.34	-1.9	0.0164	0.317	0.05	-0.4
Transfer time of 5 minutes train-train	0.0653	0.302	0.22	-1.2	0.187	0.321	0.58	-4.1
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.247	0.291	-0.85	4.4	-0.0346	0.302	-0.11	0.8
Transfer time of 15 minutes train-train	-0.863	0.294	-2.94	15.5	-0.909	0.293	-3.10	19.8
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.278	0.187	-1.49	5.0	-0.33	0.175	-1.89	7.2
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.337	0.201	1.68	-6.0	0.31	0.215	1.45	-6.8
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.146	0.203	0.72	-2.6	0.37	0.232	1.59	-8.1
Sigma BTM-train	0.171	0.284	0.60		0.28	0.238	-1.17	
Sigma train-train	1.21	0.141	8.62		0.88	0.145	6.06	
Scale parameter in-train time RP trip < 70 minutes	1.000	fixed			-			
Scale parameter in-train time RP trip > 70 minutes	0.538	0.069	-6.71		-			
Null log-likelihood	-1467.39				-1091.01			
Final log-likelihood	-1161.46				-881.05			
Adjusted ρ^2	0.189				0.166			

Appendix E12: Egress model by mode

	Bus egress				Tram egress				Metro egress			
Parameter	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT	Value	Std error	t-test	GTT
ASC BTM-Train	-0.148	0.281	-0.53	2.4	0.123	0.32	0.39	-1.9	-0.276	0.413	-0.67	3.6
ASC train-train	0	fixed			0	fixed			0	fixed		
Access time by bus												
Egress time by bus	-0.0895	0.0109	-8.19	1.4								
Access time by tram/metro												
Egress time by tram/metro					-0.0717	0.0134	-5.33	1.1	-0.0605	0.0254	-2.38	0.8
Costs, someone else pays, income < €2000	-0.356	0.0495	-7.19	5.8	-0.269	0.117	-2.30	4.3	-0.766	0.167	-4.60	10.0
Costs, someone else pays, income €2000 - €3000	-0.247	0.107	-2.30	4.0	-0.623	1.1	-0.57	9.9	-0.196	0.165	-1.19	2.6
Costs, someone else pays, income €3000 - €6000	-0.117	0.042	-2.78	1.9	-0.183	0.0569	-3.22	2.9	-0.226	0.0597	-3.78	3.0
Costs, someone else pays, income > €6000	-0.0689	0.0759	-0.91	1.1	0.0022	0.0544	0.04	0.0	-0.467	0.247	-1.89	6.1
Costs, traveler pays, income < €2000	-0.611	0.0555	-11.02	9.9	-0.511	0.0745	-6.87	8.1	-0.714	0.121	-5.87	9.3
Costs, traveler pays, income €2000 - €3000	-0.588	0.0731	-8.04	9.5	-0.396	0.0683	-5.79	6.3	-0.697	0.126	-5.55	9.1
Costs, traveler pays, income €3000 - €6000	-0.287	0.0375	-7.65	4.6	-0.548	0.0483	-11.35	8.7	-0.609	0.0745	-8.18	8.0
Costs, traveler pays, income > €6000	-0.0633	0.16	-0.39	1.0	-0.497	0.184	-2.70	7.9	-0.477	0.233	-2.04	6.2
Headway connecting mode 15 minutes	0	fixed			0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.354	0.0777	-4.56	5.7	-0.305	0.0988	-3.09	4.8	-0.435	0.126	-3.46	5.7
Headway connecting mode 30 minutes	-0.442	0.0828	-5.33	7.2	-0.711	0.107	-6.66	11.3	-0.985	0.136	-7.23	12.9
In-train time	-0.0618	0.00624	-9.90	1.0	-0.0632	0.00802	-7.88	1.0	-0.0766	0.0111	-6.89	1.0
Piecewise linear parameter for train trips > 90 minutes	0.0197	0.00755	2.61	-0.3	0.00181	0.0103	0.18	0.0	0.017	0.0151	1.13	-0.2
Transfer station medium/large	0	fixed			0	fixed			0	fixed		
Transfer station very large	0.0425	0.0673	0.63	-0.7	0.145	0.0856	1.70	-2.3	0.105	0.108	0.98	-1.4
Transfer time of 3 minutes BTM-train	-0.372	0.19	-1.96	6.0	-0.818	0.236	-3.46	12.9	0.218	0.286	0.76	-2.8
Transfer time of 5 minutes BTM-train	-0.352	0.167	-2.11	5.7	-0.187	0.196	-0.95	3.0	-0.0621	0.282	-0.22	0.8
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.845	0.135	-6.26	13.7	-0.283	0.168	-1.68	4.5	-0.834	0.22	-3.78	10.9
Transfer time of 15 minutes BTM-train	-1.33	0.137	-9.73	21.5	-0.657	0.167	-3.95	10.4	-1.11	0.221	-5.02	14.5
Transfer time of 3 minutes train-train	-0.402	0.304	-1.32	6.5	-0.198	0.349	-0.57	3.1	0.229	0.454	0.50	-3.0
Transfer time of 5 minutes train-train	0.0671	0.286	0.23	-1.1	-0.285	0.329	-0.87	4.5	-0.174	0.452	-0.39	2.3
Transfer time of 8 minutes train-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.547	0.267	-2.05	8.9	-0.314	0.31	-1.01	5.0	-0.652	0.396	-1.65	8.5
Transfer time of 15 minutes train-train	-1.31	0.265	-4.92	21.2	-1.1	0.317	-3.47	17.4	-1.22	0.383	-3.18	15.9
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.601	0.189	-3.18	9.7	-0.056	0.21	-0.27	0.9	-0.538	0.284	-1.89	7.0
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.298	0.18	1.66	-4.8	0.998	0.216	4.62	-15.8	0.064	0.276	0.23	-0.8
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.0718	0.167	0.43	-1.2	0.675	0.209	3.23	-10.7	0.303	0.282	1.07	-4.0
Sigma BTM-train	0.0577	0.279	-0.21		0.262	0.208	1.26		0.364	0.229	1.59	
Sigma train-train	1.21	0.12	10.07		0.71	0.131	5.43		1.33	0.204	6.51	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1.000	fixed			1.000	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.671	0.067	-4.92		0.619	0.072	-5.32		0.611	0.120	-3.24	
Null log-likelihood	-2040.63				-1420.95				-840.79			
Final log-likelihood	-1574.848				-1157.59				-595.98			
Adjusted ρ^2	0.214				0.165				0.257			

Appendix E13: Egress model by frequency

Parameter	Frequency high egress Value	Std error	t-test	GTT	Frequency medium egress Value	Std error	t-test	GTT	Frequency low egress Value	Std error	t-test	GTT
ASC BTM-Train	-0.061	0.244	-0.25	0.8	-0.238	0.354	-0.67	4.8	0.34	0.411	0.83	-6.0
ASC train-train	0	fixed			0	fixed			0	fixed		
Access time by bus Egress time by bus	-0.127	0.0116	-10.91	1.7	-0.0775	0.017	-4.55	1.6	-0.0708	0.0174	-4.06	1.3
Access time by tram/metro Egress time by tram/metro	-0.0735	0.0135	-5.45	1.0	-0.0316	0.017	-1.86	0.6	-0.0766	0.0209	-3.66	1.4
Costs, someone else pays, income < €2000	-0.425	0.0461	-9.22	5.5	-0.331	0.201	-1.65	6.7				
Costs, someone else pays, income €2000 - €3000	-0.114	0.099	-1.16	1.5	-0.764	0.31	-2.46	15.4	-0.804	0.418	-1.92	14.3
Costs, someone else pays, income €3000 - €6000	-0.169	0.0325	-5.22	2.2	-0.435	0.144	-3.02	8.8	-0.0442	0.0854	-0.52	0.8
Costs, someone else pays, income > €6000	-0.0411	0.0429	-0.96	0.5								
Costs, traveler pays, income < €2000	-0.632	0.0683	-9.25	8.3	-0.395	0.0649	-6.10	8.0	-0.661	0.072	-9.18	11.8
Costs, traveler pays, income €2000 - €3000	-0.51	0.0769	-6.64	6.7	-0.401	0.0593	-6.77	8.1	-0.594	0.109	-5.43	10.6
Costs, traveler pays, income €3000 - €6000	-0.479	0.0434	-11.02	6.3	-0.346	0.0465	-7.45	7.0	-0.372	0.0428	-8.69	6.6
Costs, traveler pays, income > €6000	-0.22	0.13	-1.69	2.9	-0.424	0.513	-0.83	8.6	-0.397	0.171	-2.32	7.1
Headway connecting mode 15 minutes	0	fixed			0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.452	0.0743	-6.09	5.9	-0.348	0.0999	-3.48	7.0	-0.107	0.118	-0.91	1.9
Headway connecting mode 30 minutes	-0.702	0.0787	-8.92	9.2	-0.579	0.106	-5.45	11.7	-0.415	0.126	-3.29	7.4
In-train time	-0.0766	0.0064	-11.97	1.0	-0.0495	0.00774	-6.39	1.0	-0.0562	0.00955	-5.89	1.0
Piecewise linear parameter for train trips > 90 minutes	0.00854	0.00853	1.00	-0.1	0.00371	0.00974	0.38	-0.1	0.0255	0.0106	2.40	-0.5
Transfer station medium/large	0	fixed			0	fixed			0	fixed		
Transfer station very large	0.0778	0.0628	1.24	-1.0	0.0236	0.087	0.27	-0.5	0.219	0.105	2.09	-3.9
Transfer time of 3 minutes BTM-train	0.0925	0.117	0.79	-1.2	-0.151	0.205	-0.74	3.1	-0.434	0.24	-1.81	7.7
Transfer time of 5 minutes BTM-train	-0.002	0.121	-0.02	0.0	-0.136	0.171	-0.80	2.7	0.00051	0.206	0.00	0.0
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.836	0.124	-6.77	10.9	-0.459	0.174	-2.63	9.3	-0.106	0.21	-0.51	1.9
Transfer time of 15 minutes BTM-train	-1.35	0.127	-10.67	17.6	-0.643	0.176	-3.65	13.0	-0.598	0.21	-2.85	10.6
Transfer time of 3 minutes train-train	-0.0282	0.244	-0.12	0.4	0.312	0.356	0.88	-6.3	0.202	0.407	0.50	-3.6
Transfer time of 5 minutes train-train	0.0373	0.242	0.15	-0.5	-0.0938	0.334	-0.28	1.9	0.602	0.396	1.52	-10.7
Transfer time of 8 minutes train-train	0	fixed			0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.668	0.238	-2.80	8.7	-0.536	0.331	-1.62	10.8	0.108	0.392	0.28	-1.9
Transfer time of 15 minutes train-train	-1.43	0.243	-5.88	18.7	-0.775	0.326	-2.38	15.7	-0.75	0.389	-1.93	13.3
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.433	0.176	-2.46	5.7	-0.482	0.211	-2.28	9.7	-0.241	0.251	-0.96	4.3
Sigma BTM-train	0.158	0.247	-0.64		0.0146	0.386	0.04		0.232	0.276	0.84	
Sigma train-train	1.18	0.116	10.17		0.995	0.147	6.77		0.773	0.165	4.70	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1.000	fixed			1.000	fixed		
Scale parameter in-train time RP trip > 70 minutes	0.736	0.078	-3.37		0.773	0.108	-2.11		0.704	0.113	-2.61	
Null log-likelihood	-2250.65				-1118.05				-933.67			
Final log-likelihood	-1645.824				-925.60				-761.52			
Adjusted ρ^2	0.257				0.148				0.155			

Appendix E14: Egress model by station

Parameter	Rotterdam Centraal egress Value	Std error	t-test	GTT	Den Haag Centraal egress Value	Std error	t-test	GTT
ASC BTM-Train	0.793	0.592	1.34	-15.4	-0.345	0.997	-0.35	3.3
ASC train-train	0	fixed			0	fixed		
Access time by bus								
Egress time by bus	0.0651	0.134	0.48	-1.3	-0.159	0.0799	-1.98	1.5
Access time by tram/metro								
Egress time by tram/metro	-0.0808	0.0258	-3.13	1.6	-0.0857	0.0343	-2.50	0.8
Costs, someone else pays, income < €2000	-0.647	0.291	-2.22	12.6				
Costs, someone else pays, income €2000 - €3000	-0.371	0.61	-0.61	7.2				
Costs, someone else pays, income €3000 - €6000	-0.147	0.0705	-2.08	2.9	-0.159	0.0753	-2.11	1.5
Costs, someone else pays, income > €6000					0.135	0.113	1.19	-1.3
Costs, traveler pays, income < €2000	-0.525	0.17	-3.08	10.2	-0.924	0.254	-3.64	8.7
Costs, traveler pays, income €2000 - €3000	-0.161	0.0757	-2.13	3.1	-0.674	0.18	-3.74	6.4
Costs, traveler pays, income €3000 - €6000	-0.609	0.0989	-6.15	11.8	-0.48	0.119	-4.03	4.5
Costs, traveler pays, income > €6000	-0.251	0.265	-0.95	4.9				
Headway connecting mode 15 minutes	0	fixed			0	fixed		
Headway connecting mode 20 minutes	-0.278	0.177	-1.57	5.4	0.0982	0.282	0.35	-0.9
Headway connecting mode 30 minutes	-0.821	0.202	-4.07	15.9	-1	0.326	-3.08	9.4
In-train time	-0.0515	0.0166	-3.11	1.0	-0.106	0.0237	-4.46	1.0
Piecewise linear parameter for train trips > 90 minutes	0.0273	0.0179	1.53	-0.5	0.0508	0.0289	1.76	-0.5
Transfer station medium/large	0	fixed			0	fixed		
Transfer station very large	-0.0663	0.156	-0.42	1.3	0.317	0.259	1.22	-3.0
Transfer time of 3 minutes BTM-train	-0.499	0.376	-1.33	9.7	-0.378	0.703	-0.54	3.6
Transfer time of 5 minutes BTM-train	-0.358	0.352	-1.02	7.0	-0.297	0.607	-0.49	2.8
Transfer time of 8 minutes BTM-train	0	fixed			0	fixed		
Transfer time of 11 minutes BTM-train	-0.306	0.308	-0.99	5.9	0.152	0.53	0.29	-1.4
Transfer time of 15 minutes BTM-train	-0.791	0.302	-2.62	15.4	-0.243	0.502	-0.48	2.3
Transfer time of 3 minutes train-train	0.313	0.575	0.54	-6.1	-0.0503	1.08	-0.05	0.5
Transfer time of 5 minutes train-train	0.416	0.584	0.71	-8.1	-0.123	0.933	-0.13	1.2
Transfer time of 8 minutes train-train	0	fixed			0	fixed		
Transfer time of 11 minutes train-train	-0.102	0.605	-0.17	2.0	1.1	0.963	1.15	-10.4
Transfer time of 15 minutes train-train	-1.23	0.615	-1.99	23.9	-0.154	0.945	-0.16	1.5
Extra parameter applicable with transfer time of 3 minutes and age > 60	-0.505	0.376	-1.34	9.8	-1.44	0.746	-1.93	13.6
Extra parameter applicable with transfer time of 3 minutes and travel frequency is high	0.282	0.37	0.76	-5.5	0.295	0.725	0.41	-2.8
Extra parameter applicable with transfer time of 5 minutes and travel frequency is high	0.523	0.378	1.38	-10.2	1.33	0.64	2.08	-12.5
Sigma BTM-train	0.218	0.585	0.37		0.546	0.304	1.80	
Sigma train-train	0.876	0.373	2.35		1.05	0.319	3.28	
Scale parameter in-train time RP trip < 70 minutes	1	fixed			1	fixed		
Scale parameter in-train time RP trip > 70 minutes	1.580	0.428	1.35		0.399	0.129	-4.65	
Null log-likelihood	-257.16				-304.99			
Final log-likelihood	-185.579				-249.78			
Adjusted ρ^2	0.285				0.086			