Transfer Towards European Train Travel

A stated choice experiment into the effect of train transfer attributes on long-distance leisure travel choice behaviour

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Royal HaskoningDHV
Enhancing Society Together

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A stated choice experiment into the effect of train transfer attributes on long-distance leisure travel choice behaviour

by

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Preface

Dear reader,

With great pleasure, I have immersed myself in the world of long-distance train travel over the past few months. This project has given me an incredible amount of energy and made me even more enthusiastic about the public transport sector. I have learned a lot, and I truly believe that the train is going to be the transportation method of the future in Europe. I cannot wait to dedicate myself to this topic in the next phase of my life.

I started studying in Delft almost seven years ago, in September 2017. After discovering that Applied Mathematics was not for me, I began studying Industrial Design. I did this with great pleasure, but I missed the technical depth. When I started exploring minors, I found myself drawn to transport, infrastructure, and logistics. Here, I found exactly what I was looking for: an interdisciplinary technical field with room for creativity. A year later, I enrolled in the master's program of the same name, where I felt completely at home. During the summer of 2023, while I was on the Eurostar to London for a vacation, I came up with the idea for this thesis topic. I realized how fascinating I found the journey I was making, and wondered why the plane to London was still so popular when it could also be done by train. With this in mind, I started looking for an assignment, which I eventually found with Barth at Royal HaskoningDHV.

I would like to take this opportunity to express a special thank you to some people who have helped me during this project. First of all, my graduation committee. Barth, thank you for your enthusiasm and the enjoyable brainstorming sessions we had on the subject. Especially at the beginning of the project, when I was still finding my way, your guidance was of great help. I am grateful for your candid opinions and your friendly demeanour. I appreciated the opportunity to get an inside look at RHDHV, and I really hope to encounter you again in the future. Eric, thank you for all your valuable feedback. I resonate with your way of working and have greatly benefited from all the guidance you provided. I am thankful that I could always come to you with my questions, and I have learned so much from you. Oded, thank you for the inspiring sessions we had. You quickly helped me find solutions, and whenever I encountered an obstacle, you always managed to rekindle my enthusiasm for my own project. And finally Gonçalo, you were a more distant supervisor but made all the time I spent with you worthwhile. You tell it like it is, and I really appreciated all your feedback. Thank you for offering a different perspective on my thesis and pushing me to clarify all the choices I made. Besides my committee, some others have also been of great help. I want to thank Fanchao Liao for helping me with my model in LatenGOLD, and answering all my questions about the interpretation. I also want to thank Klaas Kuipers from MWM2 for the programming and distribution of the survey, and Valerie Severens from NS for making it possible to use the NS panel. I want to thank the participants of the focus groups and pilot survey, and everyone who took the time to fill out the final survey. Finally, and above all, I want to thank my family, friends, and Nils for listening to my endless chatter about trains, and all the support you gave. Not only during my thesis, but the past seven years.

This thesis marks the end of my study time. It has been a blast, but I am ready for whatever comes next. To the reader, I hope that reading this thesis will inspire you as much as it has inspired me. Hopefully, after reading this, you will think twice before booking a plane ticket for your European holiday and maybe even look up some train alternatives. I would be very happy with that result.

Enjoy the reading!

I. M. (Ines) Roebroeck
Delft, July 2024

Summary

Introduction

Due to the pressing climate issues the world is facing, Europe is working on a transition to more sustainable means of transportation, such as trains. Especially for long-distance travel, increasing train usage can have a significant impact. However, this is not so straightforward. Unfortunately, trains often lose out to other means of transportation in various aspects. This research focuses on a part of the journey that is a big contributor to the attractiveness of the journey: Making a transfer. To enhance the attractiveness of train travel for long-distance journeys, this research investigates how transfers can be improved. Transfers are inevitable in a well-integrated European rail network, yet they are viewed very negatively by travellers. This study quantifies how a train transfer influences travellers' itinerary and travel choices by answering the main research question: 'What is the effect of transfer attributes on itinerary choice behaviour in long-distance train journeys?'

Methodology

First, the most relevant attributes to include in the research were determined. This was done through a literature review and a focus group study. The literature review examines existing similar studies, compares their results, and relates them to the context of this research. A focus group is a structured group interview in which participants discuss the topic of interest under the guidance of a moderator. Participants are free to express their opinions and can inspire each other. The qualitative setup allows feelings and perceptions to be conveyed more effectively than in a quantitative survey. The goal of the focus group is to pinpoint what the sore points of transfers are in the eyes of travellers.

Once the attributes to be studied are determined, they are incorporated into a Stated Choice experiment. In this experiment, potential users are presented with various itinerary alternatives in a survey, each varying on the defined attributes. By choosing between three alternatives each time, the underlying preferences for each attribute can be calculated, along with a willingness to pay for an improvement in each attribute. In addition to the transfer alternatives, respondents are also presented with a base alternative without transfers, and they can choose not to travel by train at all (opt-out). This way, the market potential of transfer-inclusive train travel relative to other options can be calculated.

The results are analyzed in a Latent Class Choice Model (LCCM). This is a form of discrete choice modelling where the population is split into segments (classes) that exhibit similar choice behaviour. This division is made with a class membership model, which includes covariates like socio-demographic characteristics, psychological factors, and train usage of respondents. For each class, a separate model is estimated, leading to class-specific parameters. In this way, the LCCM accounts for the heterogeneity in preference amongst the population. The differences between the classes can be interpreted by looking at the relative importance of each attribute, as well as the willingness to pay for improvements. All aspects combined create an image of what a 'good' transfer in long-distance train journeys should look like, and what the probability of choosing a transfer train alternative is based on class-membership covariates.

Conceptual model

The existing literature on transfers in long-distance train journeys is very scarce. Looking at other contexts, such as urban transit and air travel context, three types of transfer-related attributes can be distinguished: Physical, operational, and service. It is found that in urban context, operational attributes such as travel time, transfer time and travel cost were found to be most important, while in air travel context, service attributes such as insurance and staff politeness also play a big role. Physical attributes such as the presence of shops and escalators in the transfer station play a lesser role in both contexts. Based on these findings, it is decided that operational and service attributes should be included in this

research. The further specification of the attributes is done with a focus group research.

Two focus groups were conducted. In the one-hour-long sessions, the participants were asked a series of questions leading up to the key question: 'What factors do you consider when booking a long-distance train trip that includes a transfer?'. The most frequently given answers were time attributes, including travel time, separate travel times and transfer time, as well as the travel costs. Also, the amount of transfers played a big role and is therefore included in this study. Finally, the biggest shortcoming mentioned is service. The participants often compare this to flying. Therefore, this is also selected as an attribute.

Survey

With the six attributes, the survey is designed. Based on real-life examples, each attribute is varied on 2 to 4 levels. This is done in the context of trips between 700 and 850 km, like for example Amsterdam to Munich, Basel or Lyon. Each choice set in the experiment consists of 3 unlabeled alternatives. The choice experiment consists of 3 parts for each choice set.

1. The respondent is asked to choose between the three alternatives.
2. The respondent is asked to choose between the selected alternative and a transferless base alternative. This alternative is equal in each experiment. The goal of this alternative is to estimate a parameter for avoiding transfers altogether, and finding out when a transfer alternative is 'good' enough to beat a direct train. The attribute levels of this base alternative are set at the lowest utility contributions, to avoid dominance of this alternative and thus more accurate estimates.
3. The respondent is asked if considering the travel options they were given, they would choose to travel by train or opt for another mode of transportation. The resulting parameter is used to establish a respondent's willingness to travel by train and assess the potential of long-distance trains as opposed to other modes in different scenarios.

The choice sets are sequentially generated with the Ngene software package. This led to 36 choice tasks, which are divided over 4 blocks so each respondent only has to deal with 9. For these alternatives, attribute levels and blocks, the survey requires a minimum of 300 respondents.

Besides the choice experiments, the respondents are asked three other types of questions that are included in the model as covariates. First, before the choice experiments, the respondents are asked about their train usage over the past year. After the choice experiments, they are asked to rate attitudinal statements to discover psychological factors that might influence their choice behaviour. The topics of the statements are environmental considerations, personal liking of trains and train travel, and bad experiences with train travel. Finally, the respondents are asked for some socio-demographic information.

The distribution of the survey via the NS panel led to 431 responses which were a nationally representative sample in terms of gender and age.

Model

Initially, three different models were considered corresponding to the three different experiments as mentioned in the previous section. The last model includes all 5 alternatives and therefore gives the most information. However, the questions are asked separately since the comparison of a transfer alternative to a direct trip or other modes may involve dominance. However, since in the third model, the transfer option is still chosen 68,1 % of the time, this model provides enough information about the transfer attributes and is, therefore, the only model considered in the results.

The factor analysis of the psychological factors shows that the three latent factors can indeed be described by the four statements, and are converted to scores for each respondent. The nominal data is effects coded and numerical data is scaled for estimates in the same order of magnitude. Socio-demographic and train usage data is aggregated to fewer levels.

Two types of models are specified. First, a multinomial logit (MNL) is performed to retrieve average estimates from the data. Essentially, an MNL is an LCCM with only a single class and does not account for heterogeneity in the population. The transfer time attribute is assumed to be non-linear, which is why a quadratic component of this attribute is included in the model. The second model is an LCCM, which distinguishes multiple classes in the population, accounting for heterogeneity. However, as opposed to an MNL, the loglikelihood function of an LCCM is not concave but can have local optima. Therefore it is important to iterate the model with multiple starting values and find the model with the highest LL. The models are estimated in latent GOLD which is asked to generate 200 random sets of starting values which are iterated 50 times. Furthermore, the optimal number of classes for the LCCM can be determined with the BIC. A lower BIC is preferred. This resulted in a 5-class model. However, this model did not provide any additional information over the 4-class model, which is why the 4-class model is interpreted in the results.

Results

First, an MNL model is estimated. The results are listed below for each attribute. Note that these are average results.

- Travel cost has a significant negative effect on the utility of an alternative.
- Transfer time has a significant quadratic effect with a preferred optimum of about 31 minutes.
- Travel time has a significant negative effect on the utility of an alternative.
- The number of transfers has a significant negative effect on the utility of an alternative.
- Time distribution does not have a significant effect on the utilities.
- A light service level has a significant negative effect on the utilities, a premium service level has a significant positive effect on the utilities, and a standard service level has no significant effect on the utilities.
- The estimates of the ASCs of the base and opt-out alternative are also significant.

Looking at the relative importance of the attributes within the ranges of this experiment, which is also relative to the attribute level variance, it is found that travel cost (34%) and travel time (27%) are most important. Transfer time (13%) and the number of transfers (17%) are a little less important, and service (7%) is the least important, considering that time distribution is insignificant. The average VoT is found to be €11,59. The average WTP for one transfer instead of two is almost €30. Considering the VoT, this corresponds to 2,5 hours of additional travel time. The average WTP for a service upgrade from light to medium is €11,34, which corresponds to almost one hour of additional travel time.

Next, an LCCM is estimated. Four latent classes are found.

1. **Time-Valuing Eco-Advocates** (44.4%). Class 1 is the largest class in the sample and is characterised by its high VoT. They prefer to arrive at their destination quickly. They are also sensitive to transfer time and the optimal transfer time lies around 33 minutes. However, they prefer to avoid this since they are somewhat transfer-averse. Someone who has a high intention to use environmentally friendly modes is more likely to belong to this class. Since this is the largest class, the population sample (the NS panel) contains a lot of environmentally conscious people.
2. **Cost-Sensitive Train Travellers** (25,0%). Above all else, class 2 is very driven by costs. They are willing to compromise on a lot of fronts if it means they can reduce the costs of the travel. They are not time-sensitive, nor are they very opposed to making a transfer. However, they do like to travel by train and will not quickly choose another mode of transportation. Someone who is not driven by bad experiences with train travel is more likely to belong to this class. Also, in line with their cost sensitivity, people with lower incomes are more likely to belong to this class. Class 2 is the second largest class and accounts for about a quarter of the population sample.
3. **Train Dislikers** (18,1%). A significant portion of respondents from the NS panel are not big fans of long-distance train travel, and express their criticism. Class 3 accounts for over 18% of the population sample. They are likely to be indifferent to the number of transfers and transfer time, but value a good service. This aligns with the finding that they are most likely to opt for another mode over train travel. A person is likely to belong to this class when they have often travelled over long distances in the past year, but never by train. They are likely to have no intention to use environmentally friendly modes, to be driven by bad experiences with train travel and not to have a personal liking for trains and train travel.
4. **Transfer-Averse Train Sceptics** (12,6%). The final class, class 4, definitely does not like to

make a transfer. They are most likely to opt for a transferless alternative and are very sensitive to additional transfers. Class 4 is the least cost-sensitive class and is therefore willing to pay for conveniences like fewer transfers, but also to avoid bad service. When making a transfer is inevitable, this class prefers a high transfer time. People in class 4 are also somewhat likely to opt for other modes of transportation over train travel. This is reflected in the fact that a person who is driven by their bad experiences with train travel is likely to belong to this class.

Application

The results are applied to drawn-up scenarios that are based on design dilemmas. These scenarios are compared to a base scenario that resembles the current situation. A fast, cheap, high-service, good transfer, and hypothetical best-case scenario are tested. The choice probabilities of choosing either the scenario, a direct train with attribute levels equal to the base scenario, or another mode are calculated on average and for each class.

It is found that the base scenario performs quite well compared to the other scenarios as it has a high choice probability of the train options. The good transfer scenario slightly increases this probability, suggesting that a well-integrated railway network can maintain market potential despite additional transfers. However, the current European railway infrastructure needs significant development to achieve this. The good transfer scenario yields varying results across classes, with average increases in choice probability. Class 2 and Class 3, the cost-sensitive travellers and train dislikers, show the most significant gains, indicating potential focus areas for improving market share with better transfer designs.

The results are also applied to a real-life scenario. The Amsterdam-Basel case is considered, which used to be directly connected but is not anymore. It is found that the old direct train configuration is more popular than the new transfer options. However, for cost-sensitive Class 2 and indifferent Class 3, the new configuration increases train choice probability. Classes 1 and 4 are significantly more likely to choose other modes in the new setup. This indicates that while direct trips are generally preferred, offering varied transfer options can enhance long-distance train travel potential, particularly if costs are reduced. Improving service levels may also help, though to a lesser extent.

Conclusion

To conclude, while building the conceptual model, it was found that operational and service transfer attributes seem most likely to influence long-distance travel choice behaviour. The findings of the focus groups were in line with those of the literature research, which specified the operational and service attributes to include.

The model found that on average, travel cost and travel time were of the greatest importance in the context of this study. Transfer attributes are perceived as less important. For policy implications, this means that reducing cost and time should be prioritised over improving transfers to make the most impact. The service level was found to have a relatively small impact on the attractiveness of the alternative. This is in contrast with the expectations. Improving the service of train travel seems to not have a great impact on the potential of long-distance train travel. However, this attribute was simplified and quantified for this research, while in reality, it is a very complex and qualitative attribute.

Four latent classes were identified in the population sample. These are internally homogeneous, meaning that people within the class exhibit similar choice behaviour. It was found that some people prefer to travel by train, but another group of people is very unwilling to travel by train and very hard to persuade. Another part is open to the idea but encounters obstacles, including high ticket prices and train transfers. Here lies the sweet spot for improvements leading to increased potential of trains. Marketing about improvements in these areas can be specifically targeted at these groups of travellers.

All in all, a good transfer should ensure a quick connection while keeping travel costs low. The amount of transfers in a journey should be minimised, and the transfer time should ideally lie between 22 and 42 minutes. A better service can also contribute, although it is expected to contribute less. The implementation of good transfers might benefit from more European cooperation, alliances, or even a unified European transit government.

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Nomenclature

Abbreviations

Abbreviation	Definition
ASC	Alternative Specific Constant
BIC	Bayesian Information Criterion
HSR	High-Speed Rail
LCCM	Latent Class Choice Model
LD	Log-Distance
LL	Log-Likelihood
ML	Mixed Logit
MNL	Multinomial Logit
RHDHV	Royal HaskoningDHV
SC	Stated Choice
TENT-T	Trans-European Transport Network
VoT	Value of Time
WTP	Willingness To Pay

1 Introduction

1.1. Problem statement

When travelling over long distances of 300 kilometres or more, the train is a sustainable travel option as it emits 8 times less CO_2 than travelling by car and 10 times less than travelling by plane. These differences are the biggest on distances below 700 km (Milieu Centraal, n.d.), like on European level. However, on many other fronts, the train still loses in long-distance trips from other modes. Authorities in Europe, like the European Commission, advocate for an increase in train usage vis-à-vis other modes. This is done by developing rail infrastructure, opening the market to competition, and improving interoperability and safety (European Commission, 2023). To increase train usage, the attractiveness of travelling by train for passengers must be increased. This research focuses on a part of the journey that is a big contributor to the attractiveness of the journey: Making a transfer.

A one-way transit trip typically consists of multiple attributes; The access from the origin to the station, the waiting time at the station, the in-vehicle travel time, a transfer involving walking, waiting, etc., another in-vehicle time period, and finally the egress from the station to the final destination (Currie, 2005). While in any of these stages, travellers can perceive time differently from how it is actually spent, affecting the attractiveness of a journey. Different parts of the journey are perceived differently: Would you rather spend your time waiting at the station, walking towards the platform or in-vehicle? When travelling by train, factors such as comfort and reliability can also contribute to a better, or worse, time perception. Transfers have a negative effect on the travellers' time perception. Transfer time can have a more than 7 times higher impact on the market share than in-vehicle time, and thus affect the attractiveness of a trip (Gielisse, 2024). Therefore, it can be a reason for travellers not to choose the train. Because of its significant impact on time perception, small improvements in a transfer have the potential to make a great deal of difference in the overall attractiveness of long-distance train travel.

On top of that, the European railway network is expanding over limited infrastructure, making the need for transfers inevitable. Hence, they require a proper design. The transfers are essential for creating a flexible, efficient, and comprehensive network. This is crucial for accommodating the varying travel demand. Transfers also create more travel options for passengers to choose from, accommodating their varying needs and schedules, and making it possible to reach a broader array of destinations. Transfers allow train operators to optimize their timetables and routes ensuring better resource use and higher frequencies while reducing the need for extensive infrastructure development. That is why, although they can be unwanted, transfers are actually needed.

In most existing travel choice models, making a transfer comes with a fixed time penalty. This is a fixed amount of time that is added to the total travel time as a penalty when the journey involves a transfer. These penalties vary widely over studies, from as low as 5 minutes of additional travel time to as high as 20, in short-distance contexts (Bovy et al., 2008; de Grange et al., 2012; Eluru et al., 2012; Nielsen, 2004; Nielsen & Frederiksen, 2006; Nielsen et al., 2021; Van der Waard, 1988; Vrtic & Axhausen, 2002). This wide range is not surprising, considering that every transfer has different characteristics, including the place where the transfer is made, as well as every traveller has different preferences. This study evaluates which attributes of a transfer in long-distance train journeys are most important when a traveller chooses their itinerary and to what extent, while accounting for the differences in preference of travellers. It revolves around the passenger perspective, and aims to increase the attractiveness of long-distance train travel for users.

1.2. Research gaps

Research on travel choice behaviour in long-distance train travel is very scarce. This constitutes a research gap in itself. However, such studies do exist in an urban, short-distance context (Anderson et al., 2017; Chen et al., 2022; Chowdhury & Ceder, 2013; Chowdhury et al., 2014; Garcia-Martinez et al., 2018; Guo & Wilson, 2004, 2011; Iseki & Taylor, 2009; Marra & Corman, 2023; Navarrete & de Dios Ortúzar, 2013; Nielsen et al., 2021; Raveau et al., 2014; Schakenbos et al., 2016; Si et al., 2013; Xu et al., 2023; Zhu et al., 2021). These show that a transfer makes a significant negative contribution to the utility of a trip. The magnitude of this contribution depends on various transfer attributes tested in the studies. These can be divided into three main categories. First, a transfer has operational attributes. These include travel time, scheduling, transfer time, travel costs, etc. Second, there are physical attributes to a transfer. These include characteristics of the transfer station, such as the presence of stores, shelter, seating, level transfers, the presence of escalators, etc. The third category to be distinguished is service attributes. These include insurance, provision of information, reliability, comfort, security, safety, etc. In the urban context, operational attributes are the main focus. In some cases, the physical attributes are also included. The service attributes play a lesser role here. However, the operational attributes tend to weigh most heavily in the results for travellers.

Yet, travel behaviour in an urban context can be different from travel behaviour in a long-distance context. Passengers have different needs, goals, and priorities, and can thus behave differently. Therefore, it is interesting to put this in perspective with long-distance travel. By the lack of long-distance train context, some studies on transfers in air travel can be looked at (Adler, 2005; Burghouwt & Veldhuis, 2006; Choi et al., 2019; Chung et al., 2017; Coldren et al., 2003; de Barros et al., 2007). These studies show that service attributes play a much larger role here than in urban contexts. This indicates that such a difference may also exist for long-distance train travel.

As a limitation of previous studies, the heterogeneity among travellers is often mentioned. Travellers can have different preferences and therefore exhibit different choice behavior. Therefore, this behaviour is difficult to capture in a universal parameter.

The research gap thus lies in two aspects: first, no research has yet been done on the effect of different transfer attributes on the choice behaviour of travellers in long-distance train travel. In addition, previous research shows that there is a heterogeneity among travellers that has not yet been captured. This study aims to fill these research gaps.

1.3. Societal objective

Making a transition towards the train as an international, long-distance travel mode is essential in working towards sustainable development goals. However, there is still much progress to be made in this area, including significant opportunities for research as was shown in the previous section. Understanding the effect of different transfer attributes on travel choice behaviour, and quantifying the experienced disutility caused by a transfer to passengers has societal value for multiple reasons.

Making a transfer is a recognizable obstacle for most travellers, especially in a long-distance context. Many people who travel by train have experienced negative impacts of transfers on their trip. This ranges from delays or cancellations to having to transfer to a different station in a city. Since it is so relatable, improvements are expected to have a tangible impact on traveller utility. By increasing overall utility, a modal shift towards more sustainable long-distance travel can be achieved. The results of this study can carry substantial implications for transit authorities, by potentially improving ridership forecasting models. These can also be applied for policy-making purposes. For example, it can be used by the European Commission while executing the Trans-European Transport Network (TEN-T), maximizing its market potential. Improving ridership forecasting models provides better control over mobility demand, allowing potential innovations to be evaluated effectively and financial investments to be utilized more effectively.

Improving the long-distance train travel experience can lead to higher usage of environmentally friendly means of transportation in this context. It can for example result in more train travel rather than air travel. The transition towards sustainable mobility contributes to addressing the pressing environmental challenges the world is facing. Incorporating this in travel choices is vital for responsibly managing the planet's finite resources, and protecting future generations. It helps mitigate the impacts of climate change, preserving the natural world and its biodiversity.

In addition to these societal values, this project involves an internship at Royal HaskoningDHV (RHDHV), for which it is also valuable. Within RHDHV, the project is undertaken as an in-house research project. This means that the study is not directly for a client, but to strengthen the knowledge base of the company, which may be used by them as a future reference. Hopefully, this research will kick-start initiatives within the company and for its clients.

1.4. Research questions

The underlying goal of the research is to make travelling by train over long distances more attractive as a sustainable mode choice by better organizing transfers according to the preferences of travellers. To learn more about these preferences, this research addresses the following research question:

What is the effect of transfer attributes on itinerary choice behaviour in long-distance train journeys?

To answer this question thoroughly and comprehensively, the following sub-questions have been formulated:

1. What transfer attributes can influence a traveller's decision-making process when choosing a long-distance train journey through Europe?
2. How are the different attributes of a transfer in a long-distance train journey valued on average by potential users?
3. What different segments can be identified in the population, and what characteristics do they exhibit in their decision-making behaviour?
4. What does a 'good' transfer in long-distance train journeys look like?

1.5. Methods

The first research question is answered by conducting **literature research** and **focus groups**. These will be result in a conceptual model that forms the basis of this study. In the literature research, previous studies and their findings are outlined. A focus group is a qualitative research method that brings a small group of people together to share their thoughts about a topic under the guidance of a moderator. The participants are asked a series of prepared questions that unravel their feelings and attitudes towards certain aspects of the topic. The goal of this focus group is to identify relevant attributes related to transfers in long-distance train journeys, which should be included in the continuation of the study. The participants of the focus group are individuals who have experience with and knowledge of travelling by train over long distances since they are able to tell what is important from the passenger's perspective.

After the conceptual model is created, it is included in the **Stated Choice (SC) experiment**. The SC experiment entails a survey that presents the respondents with different choice sets. A choice set includes itinerary alternatives of train journeys for the respondents to choose between. Each alternative is generated from the earlier defined attributes and levels. After a respondent chooses one of the alternatives from the choice set, they are given a base alternative without a transfer, which indicates their preference and willingness to pay for such an option. The SC survey also includes questions about the sociodemographic characteristics of a respondent, as well as questions about their train usage, and psychological factors. This information is used while analysing the data, and to draw conclusions from the experiment. After a pilot, the survey is distributed to a group of respondents who are potential passengers of long-distance trains. This is done via the NS panel; a large group of people who have volunteered to participate in studies to improve the railway network. With a large number of respondents, there are no concerns about the significance of the project.

To draw conclusions from the results, discrete choice modelling is used. This can explain the choices that are made, and establish a willingness to pay (WTP) for each modelled attribute. Establishing a WTP can be useful as it makes choices monetary. Improvements can be easily expressed as a profit with a WTP, and thus can also be effectively compared with other improvements. There are several ways to model the data from the SC survey. This study uses a **Multinomial Logit (MNL) model** to estimate average results, and also a **Latent Class Choice Model (LCCM)**. This model separates the population into latent classes. Individuals within a latent class are assumed to have similar choice patterns and preferences, which leads to internal homogeneity. However, between classes, differences in choice behaviour and preferences exist, leading to external heterogeneity. The probability of observing a choice is then assumed to be a weighted sum of the choice probabilities across all classes, and the class-membership probabilities. Each class is described with a sub-model with its own parameters, accounting for the heterogeneity across the population. The classes are named which makes the result easy to interpret. Finally, the model is able to explain the itinerary choices and establish a WTP for a better transfer per class.

1.6. Report structure

This report consists of several parts. First, the used methods are described in chapter 2. This chapter explains the methods in detail and the choices that are made therein. Next, in chapter 3, a conceptual model is constructed that forms the outlines of this study. It consists of two main parts. The literature research critically reviews the current literature, in which it searches for research gaps and limitations of existing studies. It also identifies areas of interest in terms of transfer attributes. Next, the execution and results of the focus groups are described. This part specifies which attributes and covariates are included in the conceptual model. Next, the specifications of the survey can be found in chapter 4, which will explain the content of the survey and how it is constructed. Chapter 5 explains how the data was gathered and processed, and provides some specifications of the models. The results of the study can be found in chapter 6, which first covers the average MNL results, and then the LCCM results. Chapter 7 explores changes in the market share of long-distance train travel through the implementation of several scenarios. Chapter 8 draws conclusions by answering the research questions and providing suggestions for policy implications. It also addresses the limitations of the study and makes recommendations for future research.

2 Methodology

This chapter discusses the methods used in this study and explains how they work. The main methods are a literature review and focus groups to construct a conceptual model, a stated choice survey to gather data on travel behaviour given this context and these attributes, and finally discrete choice modelling (multinomial logit model and latent class choice model) to model the gathered data and draw conclusions from it. This method flow is visualised in figure 2.1.

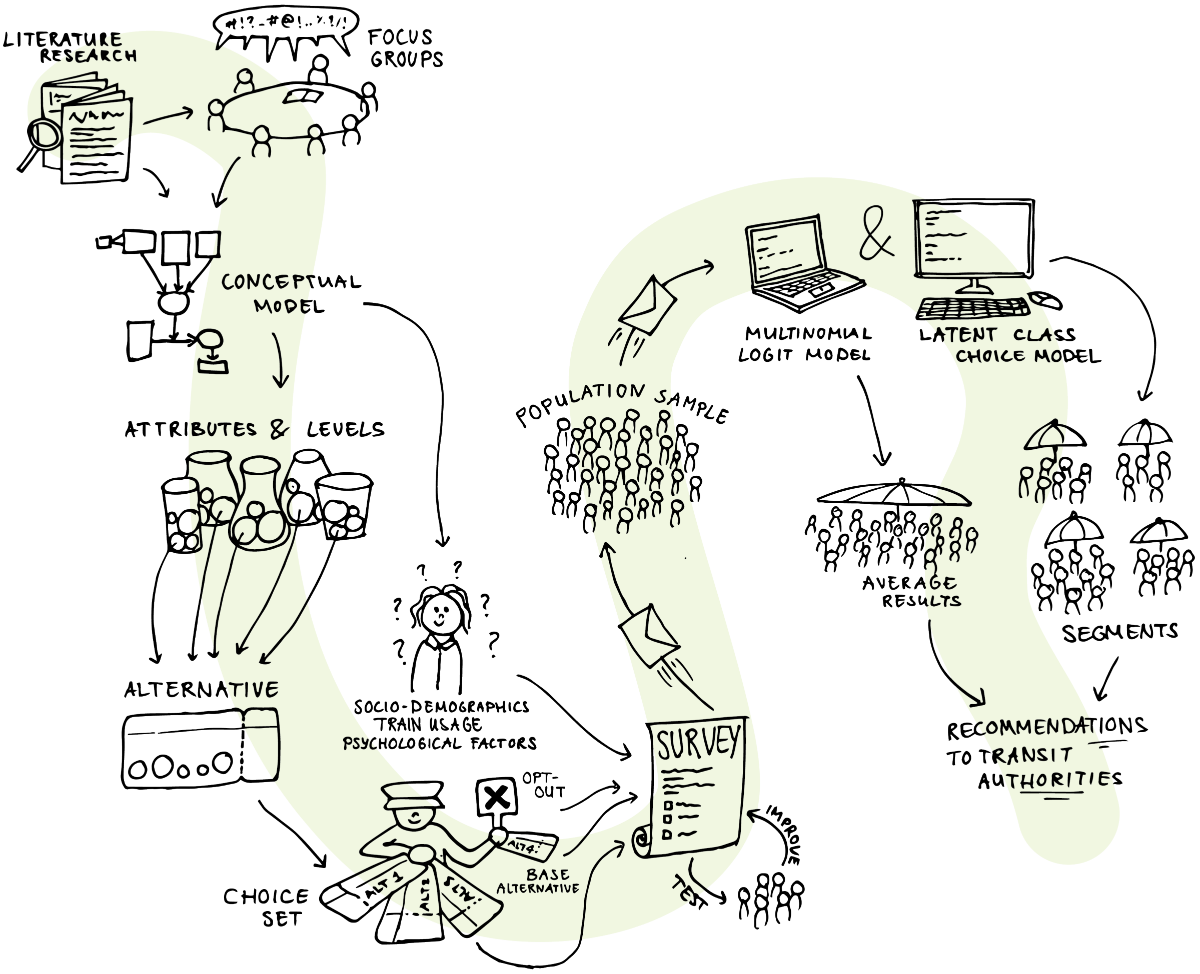


Figure 2.1: Method flow

The search strategy of the literature review is discussed in section 3.1.1. The literature review method is therefore not discussed in this chapter. This chapter discusses the theory behind focus groups, stated choice experiments, and discrete choice modelling.

2.1. Focus Groups

In order to establish the attributes to include in the survey, a focus group research was conducted. This was done according to the guidelines in the book 'Focus Groups: A Practical Guide for Applied Research' by Krueger and Casey (2014).

2.1.1. Definition and goal

A focus group is a qualitative research method that brings together a group of people to talk about a topic of interest in a moderated setting. The qualitative approach of a focus group makes feelings and perceptions come across better than they would in a quantitative survey. A focus group can include four to twelve participants per session. The group should be big enough to provide different perceptions, but small enough for every participant to be able to share theirs. In general, three or four focus groups should be conducted per category of individuals. However, since it is not the main research method of this study and the available time and resources are limited, only two are conducted. Focus groups are effective when participants feel comfortable, respected, and free to give their opinions without being judged about them. A focus group is led by a moderator, who has a neutral position towards the discussion. The questions asked by the moderator are carefully predetermined and sequenced. A focus group can have different goals, like helping with decision-making, guiding a product or program development, or providing insights on organisational concerns and issues. It is a good method to use when you want to capture feelings or ideas rather than numbers, you are trying to understand different perspectives, you want to uncover factors that influence behaviour, or you need information to design a large-scale quantitative study (Krueger & Casey, 2014). The latter is the goal of this focus group research, as it should provide insights that help with selecting relevant attributes for the stated choice survey ahead.

2.1.2. Questioning route

A focus group follows a series of questions. All questions are different and asked for different reasons. According to Krueger and Casey (2014), there are 5 types of questions.

The **opening question** is the first question asked in the focus group. All participants are asked to answer this question. The purpose of this question is to get every participant to talk early in the conversation. The opening question is easy to answer, as it asks for facts as opposed to attitudes. The answers to the opening question are not analysed, since the goal is not to retrieve information but to make everyone feel comfortable to speak. Therefore, it is important not to highlight power or status differences among participants.

Next are the **introductory questions**. These are one or more open-ended questions that introduce the topic and get participants to start thinking about it. Some options are to ask participants to tell how they see the issue/service/product under investigation, ask them how they use it, or ask for the first thing that comes to mind when they hear about the topic, etc. The introductory questions begin to give the moderator clues about the participants' views.

The **transition questions** move the conversation towards the key questions. The participants are starting to become aware of how the other participants view the topic.

The **key questions** are the questions that drive the study. There are typically 2-5 key questions. The key questions are the first questions that are developed since they are the most important. They require more time to answer, which is why it is recommended to begin at a third or halfway into the focus group.

Finally, one or more **ending questions** are asked. These bring closure to the discussion and enable participants to reflect on previous comments. Krueger and Casey (2014) identify three valuable types of ending questions.

1. "All things considered" question: This determines the final position of participants on critical areas after they have given inconsistent points of view during the focus group. It allows them to reflect on all comments shared and assign weight to them. It is important to bear in mind that the frequency of a shared topic does not equal its importance. This question can clarify that.

2. Summary question: After the moderator has given a short summary of everything that was said, the moderator asks the participants about the accuracy of this summary.
3. Final question: To ensure nothing was overlooked, the moderator asks the participants if they have missed anything, or if there is anything they wanted to say but did not get a chance to. The moderator can start this question by giving a short overview of the purpose of the study. Several minutes should be saved for this question.

Krueger and Casey (2014) also mention several ways to engage participants. A few that are selected to be potentially relevant for this study are listed below.

- Listing things: Ask the participants to make a list. This can be done plenary, where the (assistant) moderator writes everything on a flip chart (or something similar), or the participants make individual lists which are be shared afterward. The moderator can ask the participants which items on the list are most important, or which they would choose if they only get to pick one. Interactive presentation software like Menti or Slido can also be used for this purpose.
- Drawing a picture: Ask the participants to draw a picture that offers insights into their behaviour or attitudes. Let them hold up their pictures and describe what they have drawn. Compare the picture with those of other participants.
- Mind map: Let the participants write down the topic in the middle of the page and attach lines to words that come to mind. Let them hold up their mind maps, describe what they wrote down, and compare them to other mind maps.
- Drawing a diagram or flow chart: That works similarly to the previous two points, but you let the participants explain how something works. It is optional to offer them a beginning and end of their diagram or flow chart.
- Doing something before the focus group: Ask the participants to do a task before the focus group to get acquainted with the topic. This could be anything, like reviewing something, visiting a location, collecting pictures from magazines, making photographs, etc.

Krueger and Casey (2014) define seven steps to develop a questioning route. The first step is to brainstorm about the questions. The second step is to phrase the questions. It is important to use open-ended questions, keep them simple, and make them sound conversational. Avoid asking ”Why?” as this can make respondents feel confronted and make them defensive, and it implies that a rational answer should be given while the purpose of a focus group goes beyond rationality. The third step is to sequence the questions. General questions should come before specific questions, positive questions before negative questions, and uncued questions before cued questions. The fourth step is to estimate a time for each question while considering the complexity, category, level of the participants' expertise, size of the focus group, level of discussion desired, and the amount of time required to complete an activity. The fifth step is to get feedback from others. The sixth step is to revise the questions based on that feedback, and the seventh step is to test the questions.

2.1.3. Moderator

The moderator plays a key role in the focus group. Therefore, it is necessary for the moderator to be well-prepared. Not only should the content be well prepared, but the moderator's attitude towards the participants and the conversation is equally as important. According to Krueger and Casey (2014), the moderator should have the following qualifications:

- The moderator should respect the participants, and show it.
- The moderator should understand the topic and the purpose of the study.
- The moderator should communicate clearly.
- The moderator should be open and not defensive.
- The moderator should be able to get the most useful information by sensing the situation well and responding accordingly.

Some pitfalls of a focus group can be avoided with the right attitude of the moderator. Criticism of focus groups is that participants tend to intellectualise, sugarcoat situations, or even make up answers, just because they know they are participating in a focus group. This is called 'observer interference'. The answers of participants are affected by the presence of researchers or social pressure (Lanz, 2018). By asking the right questions, in the right way, and at the right time, the moderator can make participants feel comfortable enough to be honest.

2.2. Stated Choice experiment

The data for this research is gathered via a stated choice (SC) experiment. There are two types of data in a choice experiment. Revealed preference data is observed data from actual choices that were made in real-life situations. Thus, this data reflects true behaviour. However, it is limited to choices that exist in real life. In cases where participants cannot be confronted with the studied situations in real life, stated preference data is gathered. This is collected from hypothetical scenarios where individuals indicate their choices between presented options. This is usually done via a survey. It allows the study of preferences in situations that might not yet exist. Since this is the case in this study, stated preference data is generated with an SC experiment. By carefully designing a SC survey, it is possible to estimate the most accurate model.

2.2.1. Terminology

In an SC experiment, a respondent is asked to make a choice. Figure 2.2 presents a simple example of such a choice. The figure indicates four important terms that are used in an SC experiment.

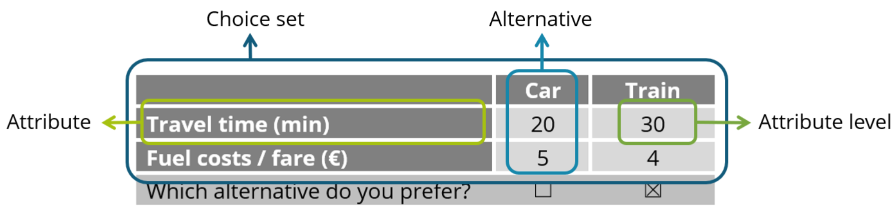


Figure 2.2: Terminology (Molin, 2022a)

An attribute is a characteristic of a choice alternative. This can be for example cost, time, distance, or comfort. The attribute level is the particular value of an attribute, and can for example be €10, 15 minutes, 2 km, or second class. The choice alternative is thus the choice option with scores (levels) on attributes. Finally, the choice set is the group of choice alternatives that a respondent can choose from (Molin, 2022a).

2.2.2. Survey construction

In an SC experiment, you want to create sufficient variation in choice situations. In this way, you can estimate parameters in a reliable and valid way. Reliable means that the parameters have small standard errors, and valid means that the estimates resemble the true parameters. To achieve this, it is important to create choice tasks that do not exhaust respondents, and construct choice situations that resemble real-world choice situations as much as possible (Molin, 2022a).

When selecting the attributes to include in the experiment, it is important to include the attributes that are most important for the respondents, so that they do not have to make their own assumptions. Furthermore, when the goal of the SC experiment is to design policies, it is important to select attributes that can be influenced by policies. In this study, the selection of the attributes is done based on the literature review and focus groups outcomes. After selecting the attributes, it is important to select the attribute levels that are relevant in the context of the study. The number of levels is typically limited to 2 to 4 (Molin, 2022a).

The selected attributes and levels are combined into alternatives. A design that includes all possible combinations of the attribute levels is classed a full factorial design. Although this is simple and allows to estimate all main and interaction effects, it usually leads to a very large design with too many alternatives. Fortunately, not all combinations are needed. Interaction effects usually do not exist in transport, so they are assumed to be zero. Therefore, the design is sufficient with a fraction of all these alternatives. This is called a fractional factorial design. Such a design can be constructed using software like Ngene. There are different types of fractional factorial designs.

- Random Design: This is a design where the alternatives are randomly selected from the full

factorial design. Therefore, the correlations between the attributes are not zero.
- Orthogonal design: This is a design where the correlations between the attributes are zero.
- Efficient design: This is a design that minimizes the standard errors. However, it requires priors. Priors are initial estimations of parameter values. These are usually based upon previous research.

This study uses an orthogonal design. Ensuring no correlation between the attributes results in much higher reliable estimates with low standard errors. An efficient design was not selected since there is no literature that uses the same specific transfer attributes in a similar context, which makes is hard to estimate priors. However, care must be taken to avoid dominance (Molin, 2022a).

Next, the generated alternatives are combined into choice sets. A choice set consist of two or more alternatives to choose from. There are two possibilities for constructing choice sets (Molin, 2022b).

- Sequential construction: Randomly place the alternatives into choice sets after they are constructed. This is applied when there are only generic attributes, and each alternative has the same attributes and levels. The alternatives are unlabeled as their names do not represent a characteristic. When constructing choice sets sequentially, it is first decided how many alternatives are in a choice set. Then, all numbered alternatives are put into some hypothetical vases, as many vases as there are alternatives in a choice sets. An alternative is randomly drawn from each vase. A redraw is performed when two or more of the drawn alternatives are the same or when a choice set was already drawn in a different order.
- Simultaneous construction: Simultaneously construct alternatives and choice sets. This is applied when not every alternative has the same attributes and/or levels. These alternatives are labeled, for example 'train' or 'car', since their names represent a characteristic (in this case mode). In simultaneous construction, all alternatives of the same label are put into a choice set randomly until all alternatives are picked exactly once.

This study uses a sequential construction as all offered alternatives are train journeys that include the same attributes and the same levels.

In the survey, the respondents are given a series of choice sets in which they are asked to choose one of the presented alternatives. To establish the potential of that alternative, the respondents are presented with a base alternative after they make their initial decision. This is a transferless option. Giving them this option puts the first choice in perspective, in which way we can establish the potential of incorporating good transfers in a train network, rather than scheduling as many direct trains as possible. A network with good transfers rather than many direct trains benefits the infrastructure occupancy and thus the overall network efficiency. On top of this base alternative, the respondents are asked if, given the travel options, they would opt for travelling by train or not. This allows for assessing the potential of the European train network in general.

First, a pilot of the survey is conducted, after which errors are taken out, and improvements are made to create the final survey. The final survey will be distributed to potential users.

2.3. Discrete choice modelling

A Multinomial Logit (MNL) model and a Latent Class Choice Model (LCCM) are estimated with the data found in the SC experiment. Both are a form of a discrete choice model. The goal of the models is to explain choices made by individuals and to predict choice behaviour. The MNL model provides average results of the entire population sample, while the LCCM divides the population sample into segments that exhibit similar choice behaviour, to account for heterogeneity. The models can establish the Willingness To Pay (WTP) for improvements in different transfer attributes and predict choice behaviour. This section explains what an MNL and an LCCM are, and how these methods are executed.

A discrete choice model is based on the principle of Random Utility Maximisation (RUM) (McFadden, 1972). This principle assumes that people will always choose the option that brings them the highest utility (U). This utility can be split into two parts; the deterministic part (V) and the error term (ϵ). The utility of an alternative i can be described by:

$$U_i = V_i + \epsilon_i \tag{2.1}$$

The deterministic component of the alternative is described by the weighted sum of all attribute values. Therefore, the utility of alternative i can be described as shown in equation 2.2.

$$U_i = \sum_m \beta_m \cdot x_{im} + \epsilon_i \tag{2.2}$$

Where i are the alternatives, m are the attributes, x are the attribute values, β are the weights or tastes to be estimated, and ϵ is the random error.

2.3.1. Multinomial Logit Model

There are several ways to model the data from the stated choice survey. A commonly used one is the MNL model, which assumes each alternative has an observed utility and a random, identically, and independently distributed error term, and uses the maximum likelihood method, which yields the set of parameters that is most likely to result in the observed sample. With an MNL model, you can estimate the probability that an individual makes a certain choice with the following formula:

$$P(i) = \frac{exp(\sum_m \beta_m \cdot x_{im})}{\sum_{j \in J} exp(\sum_m \beta_m \cdot x_{jm})} \tag{2.3}$$

Where J is the set of all alternatives that also includes alternative i (Chorus, 2021).

However, MNL is a one-size-fits-all approach and does not account for differences between respondents. It estimates a single parameter for each attribute that accounts for the entire population. Yet, heterogeneity among the population can exist when it comes to travel behaviour. In discrete choice modelling, there are some model types that take this heterogeneity into consideration. Therefore, an additional model will be estimated; the LCCM.

2.3.2. Latent Class Choice Model

An LCCM relaxes the unrealistic assumptions from the MNL model as it accounts for heterogeneity among the population, by essentially building a model of models. The model separates the population into classes. The probability of observing a choice is assumed to be a weighted sum of choice probabilities across all classes. This is shown in equation 2.4.

$$P_n(i|\beta) = \sum_{s \in S} \pi_{ns} \cdot P_n(i|\beta_s) \tag{2.4}$$

This model states that the probability of observing a choice is a weighted sum of choice probabilities across S classes. The equation states that the unconditional choice probability (probability that individual n chooses alternative i, conditional on all the model parameters β), is the sum over all classes S of the class membership probability π_{ns} (probability that individual n belongs to class s), multiplied by the conditional choice probability (probability that individual n chooses alternative i, conditional on being in class s). This makes the LCCM a model of separate choice models per class. Each class is described by a sub-model with its own parameters. The separate models per class are modelled with an MNL model. So essentially, when an LCCM with only one class is estimated, you wind up with a regular MNL. An LCCM overcomes the limitations of a RUM model since its substitution patterns are not proportional and heterogeneity amongst individuals is accounted for (Hernandez, 2023).

As discussed, π_{ns} describes the probability of individual n belonging to class s. This is estimated with the class-membership model. It is common practice to model it as a logit function, which restricts the probabilities to sum up to one. It can be described as:

$$\pi_{ns} = \frac{exp(\delta_s)}{\sum_{l \in S} exp(\delta_l)} \tag{2.5}$$

Where δ are the class parameters that provide variation to each class probability. The class and model parameters (δ and β) are estimated jointly, and one class parameter must be fixed to 0 for identification. The class parameters can either be modelled as a constant (as in equation 2.5), or as a function of socio-demographic parameters. The latter is done in this study. This changes the class-membership model to:

$$\pi_{ns} = \frac{exp(r_{ns})}{\sum_{l \in S} exp(r_{nl})}, \quad r_{ns} = \delta_s + \sum_{q \in Q} \gamma_{sq} z_{nq} \tag{2.6}$$

In this equation, δ and γ are the class membership parameters, and z are the socio-demographic parameters (Hernandez, 2023).

An LCCM is estimated using Maximum Likelihood Estimation (MLE), which aims to find the parameters that maximise the Log-Likelihood (LL) function, which is given by:

$$LL(\beta) = \sum_{n \in N} ln \sum_{s \in S} \pi_{ns} \cdot P_n(i_t|\beta_s) \tag{2.7}$$

In this function, N are the individuals in the experiment, S are the classes, π_{ns} is the class membership probability and $P_n(i_t|\beta_s)$ s the probability that n chooses alternative i_t given the parameters β_s associated with class s. By maximising this function, you can find the parameters that make choice probabilities as close to the actual choices in the dataset as possible. A risk of LCCM estimation as opposed to MNL estimation is that the function is not concave, but can have local optima. The solution to this is to try different random starting values, and choose the model with the best LL value (Hernandez, 2023). The estimation is performed in Latent GOLD, which is a software package designed for several forms of latent class analyses (LCA). It is a very user-friendly software that gives clear results. It also includes a function that picks random starting values and chooses the one that leads to the highest LL value, making sure it is not a local optimum but the actual optimum.

The number of classes to specify is chosen using the Bayesian Information Criterion (BIC). Using more classes leads to more heterogeneity being captured, which leads to a better LL. However, a better LL does not necessarily lead to a better model in this case. It can even lead to an overfitted model. The BIC selects models based on both goodness-of-fit and parsimony. It is described as:

$$BIC = -2 \cdot LL + k \cdot ln(N) \tag{2.8}$$

The BIC decreases with a better LL, but increases with a higher number of parameters (k), and therefore makes a good trade-off in the number of classes. The model with the lowest BIC is preferred (Hernandez, 2023). However, in some cases, the model with the lowest BIC does not necessarily give more insights than a model with fewer classes. Therefore, another number of classes can still be chosen if it is argued that this gives the most relevant outcome.

The LCCM was chosen over other advanced model types like Mixed Logit (ML) and Nested Logit for multiple reasons. First of all, an LCCM captures heterogeneity in a discrete manner, unlike ML which assumes continuous heterogeneity. ML still generates a single estimate and indicates how this varies over the population. LCCM on the other hand identifies distinct groups of individuals with similar preferences, which can provide more actionable insights for policy strategies to increase the attractiveness of train travel. Therefore, unlike ML and Nested Logit, it provides interpretable results that are easy to communicate. Furthermore, since LCCM allows each class to have its own set of parameters, it allows for more flexible and realistic modelling of substitution patterns among travel choices, unlike Nested Logit, which predefines a nested structure. LCCM is often used for analysing travel behaviour as it has demonstrated great model fit and predictive accuracy. It aligns with the goals of this study to unravel the effect of transfer attributes on different segments of the population, making it the most suitable choice.

The LCCM results in class parameters and model parameters for all classes and attributes. These are used to determine:

- Several classes which are given distinctive names. These names make the results easy to interpret. Examples of class names are 'Air travel lovers', 'cost-sensitive travellers', or 'experienced long-distance train travellers'. Each class consists of respondents who have similar preferences and therefore exhibit similar choice behaviour.
- The relative importance of the attributes included in the study.
- A willingness to pay (WTP) for improvements in all of the defined attributes, which can be combined into a WTP for a 'better' transfer. The value of time (VoT) can also be estimated.

The magnitude of the parameters answers the research questions by telling what the effect of the different attributes on the choice behaviour is. All these aspects combined create an image of what a 'good' transfer in long-distance train travel looks like.

3
Conceptual model

In this chapter, a conceptual model is developed which describes all the components that in some way affect the travel choice. This includes the attributes of travel alternatives, as well as covariates that may be of influence. To develop this conceptual model, we first deep-dive into the existing literature on the topic to map out the state-of-the-art and identify areas of interest for this study. Next, the contents of the areas of interest are further specified with a focus group research. Here, the goal is to test the findings from the literature review, identify specific attributes, and identify factors that might influence decision-making. Finally, the conceptual model will be presented in a graph.

3.1. Literature review

This section aims to provide an overview of the current knowledge on the subject, while critically examining the limitations of these past studies. By mapping these out, the research gap can be clearly identified, creating an area of interest for this study. First, the search strategy for finding relevant studies is clarified. After this, the found studies are presented and assessed, from which a conclusion is drawn and the research gaps are identified.

3.1.1. Search strategy

To identify the goal of this literature review, some questions were formulated. By answering these, the exact research gap is defined and the framework for the conceptual model is set. The questions are listed below.

1. What different types of transfer attributes are there and which are relevant in long-distance train journeys?
2. To what extend can the results of previous studies in different contexts be applied to long-distance train journeys?
3. What limitations of previous studies can be further investigated?

To find academic literature on this matter, several search engines were consulted. These included Scopus, Google Scholar, Mendeley and Scite. The first strand of search was into transfers in long-distance rail context. The used keywords can be found in table 3.1. However, since this led to few results and no relevant outcomes, the next strand of search was into transfers in urban transit context. To compare those results to long-distance travel, the following search focused on transfers in air travel. The keywords used in both searches are also presented in table 3.1.

The latter two search strands led to relevant papers for this literature review. Using these papers, additional papers were found by snowballing. Papers that were cited in a relevant paper were added to the literature, as some of them included literature reviews themselves. Furthermore, some of the relevant papers were cited in other papers that were also relevant and could be included in the literature review. Finally, some search engines offer a 'related documents' section, which proposes other articles that might be of interest. This function was used to find more relevant papers.

Based on the found literature, this literature review is split into urban transit context and long-distance travel context. The urban transit context first covers framework and model development studies, then unimodal studies, and finally multimodal studies. After the review, the transfer attribute types are identified and the applicability to long-distance train journeys is determined. This results in a conclusion and research gap.

Table 3.1: Keywords used in search engines

Long-distance train transfers		
Transfer as main topic:	Behavioural study:	Long-distance train context:
”Transfer characteristics” OR ”Transfer attributes” OR ”Transfer”	”Route choice” OR ”Path choice” OR ”Stated choice” OR ”Transfer choice” OR ”User behaviour”	”HSR” OR ”High-speed rail” OR ”Long-distance rail” OR ”Long-distance train” OR ”International rail”
Transfers in urban transit context		
Transfer as main topic:	Behavioural study:	Urban transit context:
”Transfer characteristics” OR ”Transfer attributes” OR ”Transfer”	”Route choice” OR ”Path choice” OR ”Stated choice” OR ”Transfer choice” OR ”User behaviour”	”Rail network” OR ”Urban Transit network” OR ”Train network” OR ”Metro network” OR ”Public transport”
Transfers in air travel context		
Transfer as main topic:	Passenger perspective:	Air travel context:
”Transfer characteristics” OR ”Transfer attributes” OR ”Transfer”	”Passenger” OR ”Passenger behaviour” OR ”Traveller” OR ”User behaviour”	”Air travel” OR ”Aviation” OR ”Airline” OR ”Airplane” OR ”Airport”

3.1.2. Transfers in urban transit networks

The first strand of research focused on transfer choice behaviour in urban transit networks, since there is a lot of research available in this context. The studies include developing frameworks and models to improve estimates of transfer component parameters and understanding of transfers, unimodal, and multimodal studies. From these studies, different transfer attribute types were identified. In table 3.2, an overview of the found literature is presented including from each study the goal, the main findings, the context, the used model, the used data, the uniqueness, and the included transfer attributes.

Table 3.2: Overview of literature on transfers in urban transit networks

Source	Topic/goal	Main findings	Context	Included transfer attributes
Guo and Wilson (2004)	Assess the transfer penalty	The found method improves the estimates of the transfer penalty, reduces the complexity of data processing, and improves the overall understanding of the perception of transfers	Subway system of Boston, USA	Walking time savings, extra in-vehicle time, transfer walking time, transfer waiting time, assisted level change
Hoogendoorn-Lanser et al. (2006)	Explaining correlations between transfer attributes	Number of transfers leads to high correlations so it is better to exclude those. Correlations are explained from the different stages of a transfer to which transfer attributes relate. The best model contains mode indicators, railway station indicators, parking costs, transfer walking times, and transfer waiting times.	Multimodal, interurban train trips, the Netherlands	Transfer walking, transfer waiting, preparing and settling, boarding and alighting, parking and retrieving, complete transfer process

The table continues on the next pages

Source	Topic/goal	Main findings	Context	Included transfer attributes
Iseki and Taylor (2009)	Clear conceptual framework relating transit waits and transfers with what we know about travel behaviour	Employing a framework that includes transfer costs, time scheduling, and five transfer facility attributes (access, connection and reliability, information, amenities and security and safety) can help practitioners better apply the most effective improvements to transit stops and transfer facilities	Various contexts (both uni- and multi-modal)	Transfer waiting cost, Transfer walking cost, access, connection and reliability, information, amenities and security and safety
Guo and Wilson (2011)	Assessing the cost of transfer inconvenience in public transport systems	Transfers pose a significant cost to LOL, and that cost is distributed unevenly across stations and platforms. Transfer stations are perceived very differently by passengers. A better understanding of transfer behaviour could significantly benefit PT systems.	Unimodal London Under-ground network	in-vehicle, entry/exit within the station, initial waiting, # stations, # transfers, transfer waiting time, transfer walking time, escalator, stairs, distance, ramp length, even transfer
Raveau et al. (2011)	Improving route choice models by adding topological variables	Adding topological (directness, user knowledge) and other novel variables (comfort) significantly improve the explanatory and predictive ability of existing route choice specifications	Unimodal metro network of Santiago in Oct 2008	In-vehicle time, waiting time, walking time, number of transfers, level changes, escalators, occupancy rate, unable to board, ride seated, network knowledge, angular cost
Arentze and Molin (2013)	Use a series of SP experiments to estimate a single comprehensive multimodal travel choice model	People are more highly sensitive for costs that are clearly visible like ticket prices and parking fees rather than fuel costs. Access, egress, walking, and waiting time weigh heavier than in-vehicle time.	Multimodal, the Nether-lands	Transfer time, walking time, waiting time, service
Chowdhury and Ceder (2013)	Psychological perspective of the inconvenience expressed by PT users when making transfers between PT modes	PT users are intolerant towards greater delays. Minimization of transfer walking and waiting times increases users' intention to use transfer routes. Most influence on intention to make transfers by reliability of transfers and reduction in journey times.	Multimodal, Auckland, New Zealand	Delay in connecting vehicle arrival, transfer waiting time, transfer walking time, security, transfer information, travel time savings
Navarrete and de Dios Ortúzar (2013)	Investigate users' subjective valuations of the transfer experience and its associated elements, and analyse how these vary for different types of transfer combinations	Walking time involved in transferring and the final walking time to the destination are most heavily penalised. Unimodal transfers are preferred over intermodal transfers.	Intermodal metro and bus, Santiago, Chile	Cost, Initial Walk time, Initial Wait time, Initial Travel time, Transfer Walk time, Transfer Wait time, Final Travel time, Final Walk time, Intermodal station, Information availability, existence of escalators, ability to board the first available vehicle
Si et al. (2013)	Developing a transfer-cost based logit assignment model	An assignment model with average errors of estimated transfer flows of below 20%, capable of reasonably reproducing passengers' transfer and route choices.	Beijing Rail transit network, China	In-vehicle time, transfer time, # transfers
Chowdhury et al. (2014)	Approximate effects of 'planned' and 'unplanned' transfers on PT users' decision to use transfer routes	Physical integration is more important than information integration for current PT users. Information integration had a greater influence on users of transfer services which are more closely aligned to being 'unplanned'.	Multimodal, Auckland, New Zealand	Transfer walking time, Transfer waiting time, shelter, information
Raveau et al. (2014)	Compare route choice behaviour between London and Santiago metro users	PT users take a wide variety of elements into account when choosing routes. London users prefer walking, Santiago users prefer waiting. Santiago users are more willing to travel in crowded trains than London. Dispreference to transfers are similar, but different attitudes to ascending and descending preferences.	Unimodal metro Santiago and London	In-vehicle time, waiting time, walking time, # transfers, ascending transfers, even transfers, descending transfers, occupancy, getting a seat, not boarding, angular cost, map distance

Source	Topic/goal	Main findings	Context	Included transfer attributes
Schakenbos et al. (2016)	Quantify the experienced transfer disutility between BTM and train	The total transfer disutility depends on the total time, distribution of the time spent and headway. In general, the most optimal transfer time is found to be 8 min.	Multimodal, the Netherlands	Access/egress time, transfer time, in-train time main trip, costs, headway connecting modes, station facilities
Anderson et al. (2017)	Model route choice behaviour while accounting for similarity across alternatives and heterogeneity across travellers	The results illustrate rates of substitution of all time components for different PT modes, composing the door-to-door experience of using a multimodal PT network.	Intermodal, Greater Copenhagen area	In-vehicle travel times, access/egress time, waiting time at transfer, walking time at transfer, # transfers
Garcia-Martinez et al. (2018)	Develop and apply a framework to estimate the value perceived and assigned by commuters to the transfer penalty	The pure transfer penalty is comparable to a 15.2-17.7 equivalent increase in in-vehicle minutes.	Multimodal, Madrid, Spain	Mode, in-vehicle time, walking time, waiting time, stairs, real-time information, crowding
Nielsen et al. (2021)	Transfer attributes effect on route choice	Travellers do consider attributes for transfers such as ease of wayfinding, presence of shops and escalators at stations when choosing routes in the PT network, attractiveness of transfer ranges from 5.4 min penalty for the best transfer to 12.1 min penalty for the worst, differences in preferences for transfer attributes across passengers	Large-scale multimodal public transport network in the Greater Copenhagen region	Appearance, Seats at platform, Safety, Security, Shop availability, Level changes, Shelters, Ease of wayfinding. Mentioned: Real-time information, Ramp length
Zhu et al. (2021)	Analysing influencing factors of transfer passenger flow to improve transfer demand analysis	There is a positive correlation between the transfer passenger flow and the node degree of transfer stations. The relationship between transfer passenger flow and the economic, geographic, and transportation locations of transfer stations is not clear	Urban rail transit, Nanjing, China	In-vehicle time, perceived transfer time, # transfers, transfer walking time, transfer waiting time
Chen et al. (2022)	Transfer behaviour from bus to rail, define more realistic station catchment areas	Intermodal transfers only 40% select nearest rail station, commuters' transfer station selections are jointly influenced by the trip attributes of all modes (mostly bus ride distance, walking distance), sensitivity to travel distances are nonlinear, location attributes play a greater role in defining the station catchment area than other attributes, stations with more amenities are likely to attract commuters from a larger area	Multimodal, city of Nanjing, China	Walking distance, route segment lengths, number of transfers, land use types surrounding stations, average daily boarding traffic at station
Marra and Corman (2023)	Effect of network disturbances on route choice	Small disturbances and delays significantly affect travel cost, although a marginal effect on route choice (72% sticks to the most likely route). Big disturbances generate less costly alternatives, but a significant effect on route choice (55% sticks)	Urban PT trips inside Zurich	Travel time, walking time, transfer time, # transfers
Xu et al. (2023)	Capture the passenger's path choice behaviours considering both the reliability and unreliability of travel time variability in the railway network	Heterogeneous passengers with different risk-aversion attitudes toward stochastic train delays evaluate their travel options differently and have different requirements for a successful transfer.	Guangzhou railway network and large Chinese HSR network	Required time for transfer, perceived transfer time

Some studies in this area focus on creating models to improve estimates of transfer parameters and understanding of transfers. Iseki and Taylor (2009) addressed the importance of modelling transfer penalties by creating a clear conceptual framework relating to transit waits and transfers. The framework suggests including both operational factors like time scheduling and transfer costs, and transfer facility attributes at stations in a decision when making improvements to transfers. Guo and Wilson (2004) created a method from a series of models that step by step included station specifics, transfer attributes, environmental effects, and demographic effects to a base model that only included a transfer constant. The method improves the estimates of the transfer penalty and the overall understanding of the perception of transfers. Si et al. (2013) developed an assignment model that is capable of reasonably reproducing passengers' transfer and route choices.

Another set of studies assessed transfers in unimodal networks. Raveau et al. (2011) added topological variables to the model and found that these significantly improved the explanatory and predictive ability of route choices. These variables included directness, user network knowledge, but also comfort. Guo and Wilson (2011) found that transfers pose a significant cost to a trip, but that cost is not evenly distributed across different transfer locations, indicating heterogeneity amongst transfer attributes at different stations. Later, in a joint research, Raveau et al. (2014) compared the two assessments (London and Santiago metro) and found a wide variety of elements taken into account by users when choosing routes. Although both user groups dislike transfers, they do so for different reasons. This also indicates heterogeneity amongst passenger preferences regarding transfers. Zhu et al. (2021) found a positive correlation between transfer passenger flow and the node degree of the transfer stations (to how many other stations a station is directly connected), which is intuitive and logical. However, the relation with other transfer station location attributes remained unclear. All four mentioned studies use observed trip data in their research. This is easily accessible for unimodal networks. However, it was more difficult to obtain data about transfer attributes (Guo & Wilson, 2011) and the full journeys could not be described due to the unimodality (Raveau et al., 2011).

Finally, there is a set of studies assessing transfers in multimodal networks. Navarrete and de Dios Ortúzar (2013) found that multimodal transfers are more heavily penalised by travellers than unimodal transfers. The most heavily penalised attributes were found to be walking time in the transfer and to the final destination. Chen et al. (2022) aimed to define more realistic station catchment areas based on transfer behaviour and found that commuters select their transfer stations based on trip attributes of all modes. Schakenbos et al. (2016) found that the multimodal transfer disutility depends on the total travel time, the distribution of how this time is spent and the headway, which led to a most optimal transfer time of 8 min. Garcia-Martinez et al. (2018) estimated the pure transfer penalty to be a 15.2-17.7 minute increase in total time perceived, while Nielsen et al. (2021) estimated the transfer penalty to be 5.4 minutes for the best transfer and 12.1 min for the worst, while considering that travellers also include characteristics of transfer stations in a route choice. However, they acknowledge a difference in preference across passengers. To account for similarity across alternatives and heterogeneity amongst travellers, Anderson et al. (2017) modelled route choice behaviour resulting in substitution rates for all time components of a trip for different PT modes. Most of these studies used stated preference (SP) surveys to obtain the data. However, the data about the transfer attributes was often not very detailed.

Some studies have a specific focus on the reliability of transfers by including network disruptions in their research. For example, Chowdhury and Ceder (2013) proposed a psychological perspective of the inconvenience expressed by PT users when making transfers between PT modes. They found that PT users are intolerant to greater delays and that the most influence on intention to make transfers comes from the reliability of a transfer and reduction in travel times. Later, Chowdhury et al. (2014) approximated the effects of planned and unplanned transfers on travellers' decision to use a route. They found that for users of transfer services, information integration had a greater influence than physical integration, which is more closely aligned with unplanned transfers. This means that transfer reliability is once again considered very important. Marra and Corman (2023) estimated the effect of network disturbances on route choice. They found that small disturbances and delays have a significant effect on travel cost, but less on route choice, while big disturbances generate less costly alternatives, but have a significant effect on route choice. This was based on data from urban PT trips inside Zurich. Xu et al. (2023) looked at passengers' path choice behaviour considering the reliability of travel time variability in smaller rail networks and a large HSR network. They found that passengers have different risk-aversion attitudes toward stochastic train delays, they evaluate travel options differently, and they have different requirements for a successful transfer. This heterogeneity makes it hard to capture a general value for a transfer penalty.

3.1.3. Transfers in long-distance journeys

The aforementioned studies have been conducted in urban, short-distance contexts. Research on transfers in long-distance train travel is scarce. However, it is argued that it would be bold to assume that a direct comparison between urban and long-distance travel can be made. To gain more insight into transfers in a long-distance context and how these relate to an urban context, some studies on transferring in air travel have been looked at, since this is more available. Table 3.3 provides an overview of several studies with relevant findings on transfers in this context.

Table 3.3: Overview of literature on transfers in air travel journeys

Source	Topic/goal	Main findings	Context	Included transfer attributes
Coldren et al. (2003)	Modeling aggregate air-travel itinerary shares	Connection quality, carrier market presence, and airfares are important attributes to determine the value of an itinerary	United States	Level-of-service, connection quality, carrier, carrier market presence, fares, aircraft type, time of day
Adler (2005)	Present a model structure that analyses the hub-spoke network design issue within a competitive framework	Air-travel itinerary and transfer choices can be largely explained by the flight frequencies, airfare, value of time, and other airline competition characteristics	Western Europe	Airfare, service frequency, value of time, maximal demand
Burghouwt and Veldhuis (2006)	The competitive position of hub airports in the transatlantic market	It is important for the airport to facilitate flight transfers among the airlines belonging to the same alliances	Market between Northwest Europe and the United States	Connectivity, alliance membership
de Barros et al. (2007)	Analyse transfer passengers' views on the quality of services at the terminal building	Transfer passengers place a great deal of value on the treatment they receive from the security check staff	Sri Lanka, hub for South Asia	Quality of guidance/signage/directions, quality of audio information/information staff, quality of flight information displays, seat availability in transfer area, drinking water availability, courtesy/helpfulness of security staff
Chung et al. (2017)	Investigate competitiveness of three major transfer airports	Airport brand is the most important attribute for competitiveness of an airport, followed by cost, connectivity, and duty-free shops	Airports in Northeast Asia connecting Southeast Asia and North America	Airport brand, landing charges, number of connecting cities, sales of duty-free shops
Choi et al. (2019)	Determine factors affecting air passengers' transfer airport choice	Transfer airport choice is affected by airport's characteristics, including minimum connection time and service quality of the connection, in addition to airfares and travel time	Market between Southeast Asia and North America	Frequency, size, service level, minimum connection time, detour degree, fare

From these studies, it becomes clear that travellers in these long-distance air journeys with a transfer at an intermediate airport value service very much (Burghouwt & Veldhuis, 2006; Choi et al., 2019; de Barros et al., 2007). For example, they value staff politeness, and having insurance for a refund in case a transfer is missed, as well as assistance in finding alternative travel options when this happens. Travellers also value the image of the operating airline in comparison to competitors (Adler, 2005; Chung et al., 2017; Coldren et al., 2003). Competition characteristics and quality branding are often mentioned in the studies. Furthermore, frequency, travel time, and airfares are also mentioned as contributing factors (Adler, 2005; Choi et al., 2019; Chung et al., 2017; Coldren et al., 2003).

However, it is once again argued that a direct comparison between air transfers and train transfers cannot be made. In airports, flights are often segregated between intercontinental and short-haul flights. This allows for providing different services to different types of travellers. On top of that, airports are closed when you pass security, which is mostly not the case in train stations. The consequences of these differences should be further examined in the study.

3.1.4. Transfer attribute types

In the most right column of table 3.2 and 3.3, the included transfer attributes are indicated per study. After analysing the found literature, three types of transfer attributes were identified: Physical, operational, and service.

Physical transfer attributes include the physical characteristics of a transfer station. These attributes include aspects like shelter, presence of stairs, presence of escalators, presence of real-time information, crowding, distances within the station, ramp length, level/even transfers, amenities, appearance, presence of seats on the platform, shop availability and ease of wayfinding (Chowdhury & Ceder, 2013; Chowdhury et al., 2014; Chung et al., 2017; de Barros et al., 2007; Garcia-Martinez et al., 2018; Guo & Wilson, 2004, 2011; Iseki & Taylor, 2009; Navarrete & de Dios Ortúzar, 2013; Nielsen et al., 2021; Raveau et al., 2011, 2014).

Operational transfer attributes include aspects that define the itinerary of a trip, like access/egress time, in-vehicle time (before and after transfer), waiting time at transfer, walking time at transfer, number of transfers, and travel costs. Every study in this overview includes at least one of these attributes.

Finally, there are service attributes, which include aspects that enhance the quality of the travel experience by offering good service to the traveller. These include attributes like reliability, comfort, security, safety, probability of delay (Chowdhury & Ceder, 2013; Iseki & Taylor, 2009; Nielsen et al., 2021; Xu et al., 2023), but also includes alliance membership, employee service and insurance (Adler, 2005; Burghouwt & Veldhuis, 2006; Choi et al., 2019; Chung et al., 2017; Coldren et al., 2003; de Barros et al., 2007).

From the results of the studies included in this overview, it becomes clear that in an urban context, time attributes (waiting, walking, in-vehicle) are always considered very important, but physical attributes are also considered by travellers when these were included in the experiment. Service attributes are included less and have less significant results, except for reliability, which is mentioned as an important factor in the study of Chowdhury and Ceder (2013). In the long-distance air travel context, service attributes play the most prominent role.

3.1.5. Conclusion and knowledge gap

The findings from the air transfer studies are different from the studies conducted in an urban context, where time and costs are mostly the dominant determining factors. It seems that in these long-distance journeys, it is considered more important to arrive comfortably and easily at the destination rather than arriving at the destination as quickly and cheaply as possible. This indicates that there may also be similar differences with transfers in long-distance train journeys. Especially considering that there hasn't been much research done on the topic and thus little is known about it yet, this leads to an interesting knowledge gap to investigate. Specifically, it is expected that there is much to be gained in the area of service attributes, as these also played a significant role in the results of the air transfer studies. Also, operational attributes are interesting to include, since these are found to be important in both contexts and can go hand in hand with service attributes like reliability. After finding out which exact attributes are most relevant in a long-distance context, a willingness to pay (WTP) can be calculated by including cost as an attribute in the SC survey.

In addition to investigating which attributes have an impact, it is also interesting to capture the heterogeneity among passengers. Many studies explicitly mention that preferences vary among travellers, but this is rarely captured. Including this in the research will give a more realistic outcome. Providing this information will also make the results easy to interpret and apply. This will allow for well-considered recommendations to be conveyed to transit authorities.

3.2. Focus Groups

The goal of this focus group research is to identify relevant attributes to include in the conceptual model, which will form the basis of the survey. On top of that, it will identify other factors that might be of influence to include in the model. This section explains how the focus groups were executed and what their main results are.

3.2.1. Questioning route

First, the questioning route was determined. In table 3.4, a set of questions was brainstormed and phrased per question category. The sequence of the questions is indicated, as well as the estimated time per selected question. A total of 10 questions are asked in a total time of approximately 1:25 h.

Table 3.4: Questioning route

Category	Question	Place	Time
Opening question	What is your name, when was the last time you travelled by train (long distance), where did you travel to and what did you do there?	1	5 min
Introductory questions	What is the first thing that comes to mind when you think about long-distance train travel?	2	5 min
	What are (for you) reasons to travel by train over long distances?	X	X
	When do you choose to travel by train over long distances?	X	X
	Make a drawing or diagram of what a long-distance train journey looks like. Can you explain what you drew?	3	5 min + 5 min
Transition questions	What are the advantages of travelling by train over other modes?	4	10 min
	(Follow up) What are the disadvantages of travelling by train?	X	X
	What do you worry about when travelling by train over long distances?	5	10 min
Key questions	Please make a list of all the factors you consider when booking a long-distance train trip that includes a transfer. Can you explain what you mentioned?	6	5 min + 10 min
	(Follow up) Which factor is the most important?	7	5 min
	What does the best possible transfer for a long-distance train trip look like?	8	10 min
	What makes a transfer a bad transfer?	X	X
Ending questions	All things considered, what are the most important factors you consider when choosing a transfer itinerary?	9	5 min
	Have we missed anything? Is there anything that we should have talked about but didn't? Is there anything you came wanting to say but didn't get a chance to say?	10	10 min

X = question was not selected to be in the final questioning route

The third and sixth questions are questions to engage the participants. For drawing the flow chart or diagram (question 3), the participants are provided with a piece of paper and a pen. After they have finished, they are all asked to hold up their paper and discuss what they drew. For the sixth question, a Mentimeter is started on the screen in the room, to which the participants can send their answers. Every given answer is displayed on the screen in a wordcloud. If an answer is given multiple times, the answer becomes bigger in the wordcloud. The words in the wordcloud are then discussed.

Since the focus group was conducted in Dutch, the Dutch translations of the questioning route can be found in appendix B.

3.2.2. Participants

To obtain reasonable results from this focus group, the participants are experienced long-distance train travellers. Two focus groups were conducted. The first one took place on Wednesday 27th of March with six participants, coming from my personal circles. These included friends, family, and fellow students. They were asked to participate based on their experience with long-distance train travel and/or their knowledge of the subject. The focus group got together in a room in the building of Civil Engineering and Geosciences, where the participants were provided some home-baked goods during the session. The second focus group took place on Tuesday 2nd of April at the RHDHV office in Utrecht. Five colleagues participated in the session. These were colleagues who worked in the departments of Rail and Mobility Hubs. These participants were also provided with home-baked goods during the session. According to Krueger and Casey (2014), eating together has a positive effect on the conversation and communication within the group. It also helps as an incentive for people to be willing to participate. The two focus groups are essentially different, as the second group includes experts in the field of train travel. They were asked to view the topics from the passenger's perspective.

In preparation for the focus group, the participants are asked to fill out a small survey. The information they provide in this survey is used for three causes: It gives an understanding of who participated in the focus group and potentially identifies limitations, it prepares participants for the session, and it is a first pilot of what information might be relevant for the SC survey. The complete survey content can be found in appendix C.

The survey consists of 4 parts. First, some sociodemographic information of the participants is asked. This includes their gender, age, employment status, education, province of residence, marital status, and car ownership. Secondly, their attitude towards certain topics is asked. They are given 10 statements and are asked to indicate how much they agree with the statements on a Likert scale. The topics of the statements are: Environmental consciousness, value of time, cost-orientedness, impulsiveness when making choices, affinity towards train travel, safety in train stations, ease of giving up, value of comfort, stress about making transfers, and willingness to avoid transfers. The third part asks the participants about their travel behaviour. This includes how often they travel by train, how many long-distance trips they made in the past year, how many of those were by train, their travel motives, their travel companions, their preferred mode for long-distance trips, and their motivation for that. The final part is a small preparation for the focus group. They are asked to think about the following question: "When planning a long-distance train trip (300+ km) that includes a transfer, what do you pay particular attention to, and based on what factors do you make your itinerary choice?". They are allowed to write down some keywords to bring to the session, or simply just think about it in advance. They are asked to not discuss their answers with other participants in advance since this discussion is the purpose of the focus group. The goal of this preparation is to help the discussion along, and not waste too much time on thinking. If the participants have already thought about it, they can immediately share their opinions and start interacting with other participants about it.

Based on the information provided in the preparation surveys, an overview of the participants' characteristics is given in figure 3.1.

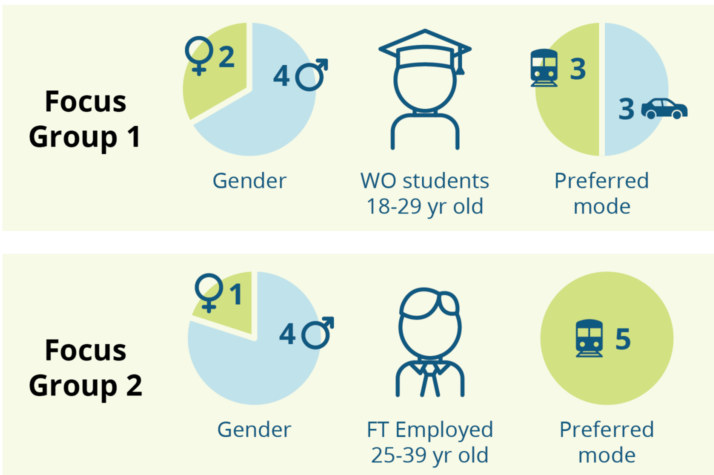


Figure 3.1: Focus group participants overview

3.2.3. Results

The focus groups were successfully conducted. Figure 3.2 shows the setting of both focus groups, with the first focus group in figure 3.2a and the second in figure 3.2b.

(a) Focus Group 1

(b) Focus Group 2

Figure 3.2: Focus Group settings

For each question in the focus groups, the main takeaways are presented. The first question is not considered as the purpose of this question was not to retrieve information, but to make everyone feel comfortable to speak. Questions 9 and 10 are also not separately discussed as their purpose was to clarify everything for the researcher, and additional comments were added to the questions they belonged to. Quotes given in this section are translated from Dutch.

2. What is the first thing that comes to mind when you think about long-distance train travel?

The participants were asked to call out anything that came to their minds. Transfers are mentioned very quickly in both focus groups. However, the respondents were aware that this is the topic of the research. Other things that are mentioned are comfort, leg space, night trains, reserved seating, delays, Europe, carrying luggage, reading a book, having enough room for your stuff, accessible internet, fear of being too late, and fear of missing a transfer. These answers were already in the direction of the key questions. The participants mainly mention experiences. It is interesting to see that transfers play a prominent role in their answers.

3. Make a drawing or diagram of what a long-distance train journey looks like. Can you explain what you drew?

This question was only asked in focus group 1 due to the time limitations of focus group 2. The drawings that were made for this question are shown in figure 3.3. After first making these drawings in silence, the participants were asked to explain what they drew.

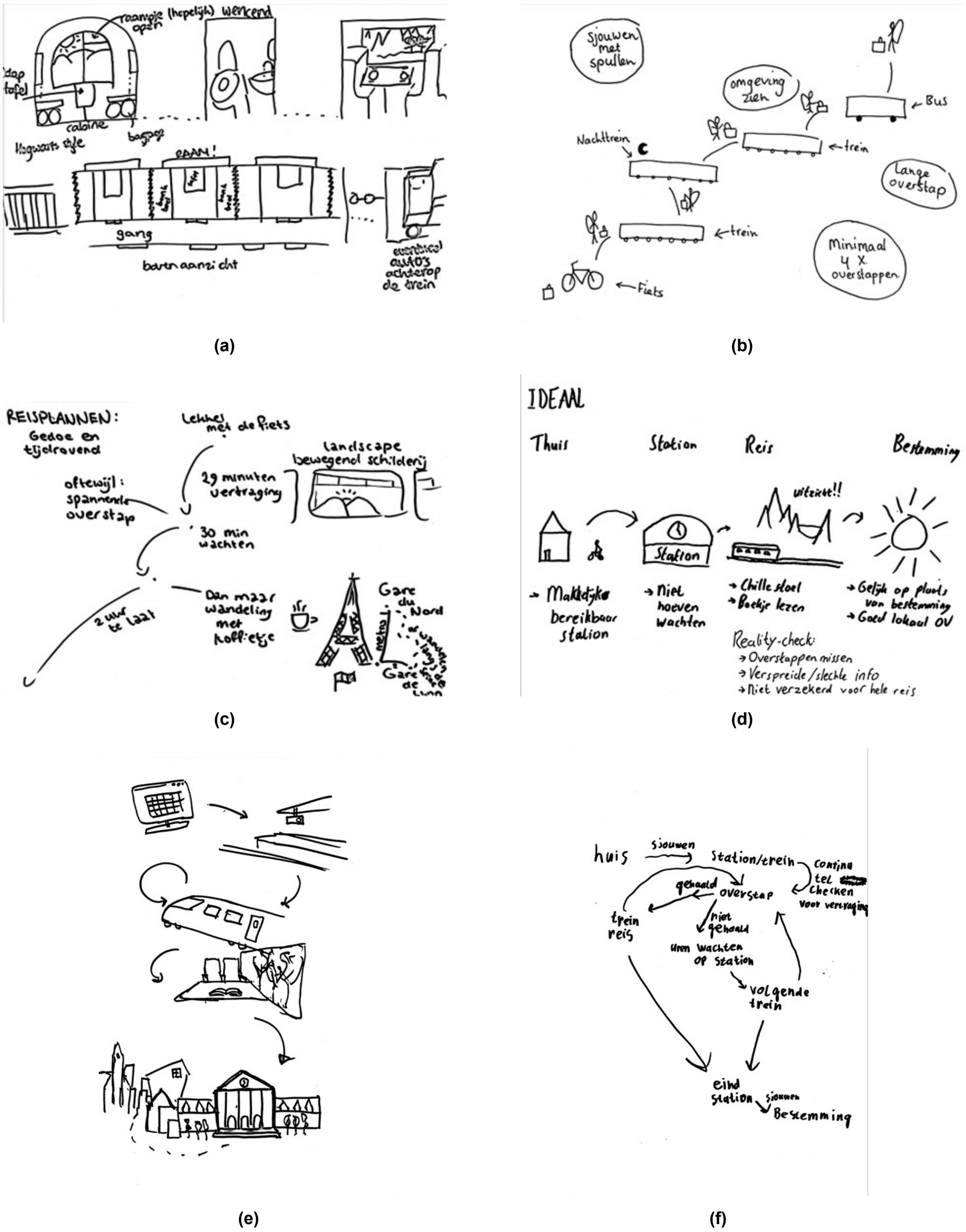


Figure 3.3: Focus group question 3 drawings

It is interesting to see that almost all drawings (except 3.3a) include one or more transfers. This implies that the participants associate long-distance train travelling with making transfers. In most of the cases, the transfers were explained as a negative factor in the journey. The romance of train travelling was reflected several times in the drawings, as nice views and leisure activities were drawn. The intermodality of the full journey is reflected a few times, as well as the unreliability of trains that comes with stress for the traveller. 'When I'm on the train, I constantly check my phone for updates on my trip and possible delays', one participant said. This exercise really got the conversation starting.

4. What are the advantages of travelling by train over other modes?

The participants came up with several themes. One of the themes was comfort. Room to move and walk around was mentioned in both sessions and also other facilities like power sockets, on-board bistros, and easy access to toilets were mentioned. The ease of travel as opposed to air travel was mentioned, as you usually do not have to go through security or customs. Both groups mentioned the safety of the modes as opposed to car travel, and the fact that you do not have to pay attention when you do not have to drive. The fun and romance of travelling by train were also mentioned in both groups. Finally, the environmental impact was briefly mentioned.

5. What do you worry about when travelling by train over long distances?

This question provoked more conversation than the previous one. A main aspect that was mentioned in both focus groups is service. 'There is little information available, and the available information is scattered over different platforms. The online service is limited, which makes calling customer service necessary. You don't get offered any alternatives and there is poor cooperation', was said in the first focus group. 'Train travel requires a relatively high level of self-reliance from travellers. Some people have a sense of humour about that, but most people are not keen on it', was said in the second focus group. This level of service is then compared with aviation in both groups, where, as a traveller, you have much less to worry about. This lack of service is closely related to the punctuality of the trains, which is mentioned as a sore point in both focus groups. They say that they worry about it, especially in regions that are known to be not punctual, like Germany. They also worry about the consequences of missing a transfer; getting crammed into the next train, or not being able to reach your destination at all. Other things that were mentioned are not having a working toilet available and having to carry your luggage to, between, and from the trains. From these answers, it becomes clear that transfers definitely bring headaches to travellers.

6 & 7. Please make a list of all the factors you consider when booking a long-distance train trip that includes a transfer. Can you explain what you mentioned? Which are the most important?

These were the key questions of this focus group. In the first group, the respondents could link to a Mentimeter to answer the question. Their responses were put in a word cloud. The second group did not use the Mentimeter but the answers were put into a word cloud manually. The translated versions of the word clouds are shown in figure 3.4. Many attributes were mentioned, so the only main takeaways and interesting findings are discussed.

(a) Word cloud focus group 1 **(b)** Word cloud focus group 2

Figure 3.4: Word clouds of important attributes

Both groups agreed that total travel time and costs are important attributes to travellers. Also, the number of transfers and transfer time played big roles in both groups. They linked the presence of a transfer to service and comfort attributes. To quote a participant from the focus group 2: 'I would rather not make a transfer, but often that is unavoidable in long-distance train travel. Then I like to have the means to pick the most pleasant one.'

In terms of travel time, a participant in the first focus group stated that they would travel up to 16 hours by train, not longer. 'Then I can separate the travel time into four blocks of 4 hours, which is doable for me'. Another participant argued that they would rather have one very long part in the trip since this would be least sensitive to disturbances. The second focus group argued that it is dependent on your personal preference, but also your travel companions. 'When I travel with my young kids, 4 hours is pretty much the longest they can be in one place. So in a trip of 12 hours, I would rather make an extra transfer and split it into three parts of 4 hours than have two parts of 6.'

8. What does the best possible transfer for a long-distance train trip look like?

Both groups agreed that in operational terms, this is very dependent on the travel context, like the route, length, companions, etc. In some cases, it would be best to factor in a long transfer time, while in other cases you can assume high reliability and thus a shorter transfer time suffices.

Focus Group 1 came up with an ideal transfer together. In the ideal situation, you would have a transfer guarantee, meaning the second train waits for the first train to arrive. The transfer would be short and on the same platform, unless you would want to have a nice lunch or cup of coffee in one of your intermediate cities. There would be a safe place to store your luggage or the transferring of the luggage would be done by the operators, like in air travel. There would be a heated or cooled waiting area with plenty of facilities to use.

3.2.4. Conclusion

From the focus groups, it is concluded that costs and time attributes should definitely be included in the experiment. The time attributes can be split into total travel times, separate travel times, and transfer times. The number of transfers also plays a big role in a traveller's choice behaviour. Finally, service is also a big sore point of long-distance train travel, and therefore interesting to include. This service attribute can include multiple levels, like insurance, customer care, luggage management, and alternative travel options in case of a missed transfer. Passengers tend to compare this level of service to the level of service in air travel. The final list of attributes is as follows:

- Travel cost
- Travel time
- Number of transfers
- Transfer time
- Time distribution (separate travel time of each train)
- Service

Some other attributes found in the focus groups were deliberately not included in the survey. These are the physical transfer attributes found in questions 5 and 8. These include things like toilet availability, luggage carrying, facilities in the station, and safe storage space in stations. This exclusion results from the findings in the literature review, where the physical transfer attributes are found to be relatively unimportant. On top of that, they were only mentioned in one of the two focus groups, where the participants got a bit caught up in physical attributes. The second focus group did not confirm the importance. Therefore, they were also chosen to be excluded from this study.

Heterogeneity amongst different travellers can also be observed in these focus groups. People have different preferences and behave differently, even within these small groups of people who come from the same context. Thus, it is important to take this into account in the study. Besides socio-demographic variables, it is interesting to include some other factors. In the focus group, it was found that people tend to adjust their behaviour based on psychological factors. As these are psychological factors, they cannot be directly tested with a single question. They will be measured with several statements and a factor analysis. Three main factors are identified as follows:

- Environmental considerations
- Personal liking of trains and train travel
- Bad experience with train travel

On top of these psychological factors, the training usage of the participants also plays a role. For example, more experienced long-distance train travellers look at other things when choosing an itinerary than inexperienced travellers, and someone who travels with their family prioritises other aspects than someone who travels alone. Therefore, the following aspects of train usage are included in the conceptual model:

- General train use (domestic, day-to-day basis)
- Number of long-distance trips made in the past year
- Number of long-distance train trips made in the past year
- Motive for travelling long-distance
- Company while travelling long-distance

3.3. Conceptual model

Finally, all the found elements are combined into the conceptual model on which the survey is based. Figure 3.5 graphically represents the conceptual model. The format of the graphic was inspired by Weisshaar (2024). Note that the arrows represent effects and not inputs.

In the top left of the figure, the factor analysis is shown. In this analysis, the psychological factors are measured with rated attitudinal statements. The upper part of the figure represents the class-membership model, which determines a person's class membership probability based on psychological factors, train usage and socio-demographics. The lower part of the figure represents the class-specific choice model. In the MNL, no classes are considered so only the lower part will be used.

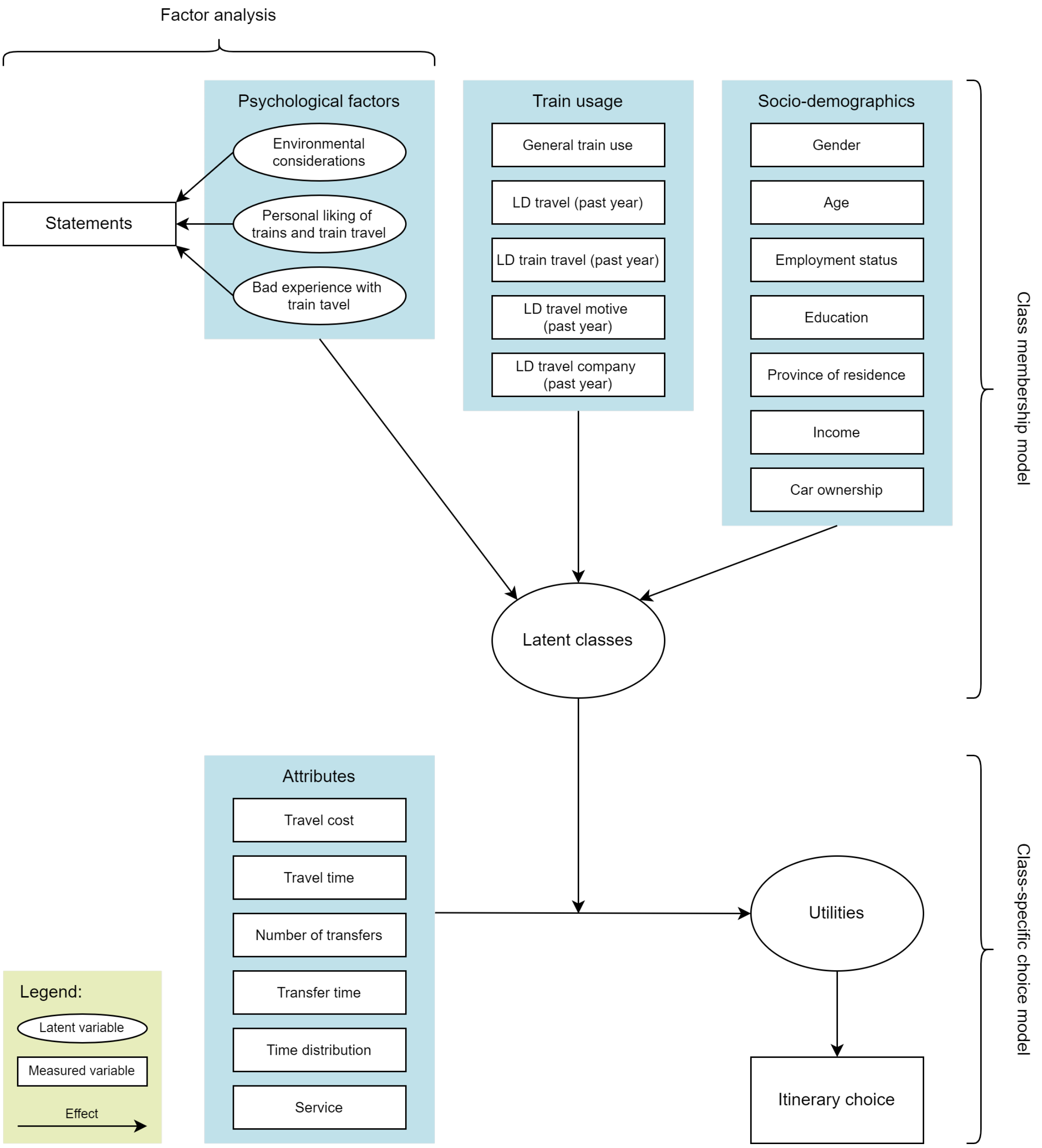


Figure 3.5: Conceptual model

4
Survey design

This chapter presents the specifications of the survey conducted for the SC experiment. It is constructed based on the conceptual model as presented in chapter 3. First, the content of the survey is further explained and an example of how alternatives are presented is given. Finally, the construction of the survey is addressed. The choice sets are generated using the Ngene software package.

4.1. Survey content

The SC survey will have the following structure:

1. Introductory text from the researcher who thanks the respondent for participating, explains the context of the research, and introduces the topic.
2. Questions about the train usage of the respondent in both short and long distances.
3. Explanation of the choice context and alternatives.
4. The choice experiment, including the choice tasks, base alternative, and opt-out.
5. In-depth statements about the respondent's attitude towards topics, to determine psychological factors that might influence their choice behaviour.
6. Socio-demographic characteristics of the respondents.
7. Word of gratitude and room to leave comments.

4.1.1. Train usage questions

In these questions, the respondents are asked about their train usage. These are easy-to-answer questions about how often they travel by train on both short and long distances. The respondents are asked to state facts, not opinions, since that might influence the choice experiment. These questions include what their travel motives over long distances usually are, who they usually travel with, how often they travel long-distance, and how often they travel by train. This information is used as covariates in the model, as it is expected that these factors influence class membership. The questions are asked before the choice experiment to get the respondents acquainted with the topic. The train usage questions are multiple-choice questions.

4.1.2. Choice context

In the choice context of this experiment, the total travel distance for each alternative is fixed. In this way, the alternatives are easy to compare and the attributes (explained in section 4.1.3) can be varied. The choice context of the experiment is chosen to be train journeys of between 700 and 850 kilometres. This distance was chosen for two main reasons. Firstly, at this distance, train travel is competitive with air travel (Adler et al., 2010), and has a significant market share (Donners, 2016). This means that improvements have the potential to be very impactful in this area. Secondly, direct trains hardly exist at these distances, which means transfers are inevitable and feel natural to travellers. It is also the travel distance in which additional transfers could lead to increased efficiency and integration of the network. This makes for an interesting choice context given the nature of the study. The respondents are provided with some examples of journeys over these distances for better imagination of the alternatives. Since the respondents are Dutch, the examples originate in Amsterdam. The provided examples are:

- Amsterdam - Munich (∼800 km)

- Amsterdam - Basel (~750 km)
- Amsterdam - Lyon (~850 km)

These examples are also used in determining the attribute levels in the next section.

Besides the travel distance, it is also decided to fix the travel context in terms of motive and company. In this way, it is easier for the respondents to relate to the travel choices as they can imagine a specific situation. It is decided to focus specifically on leisure trips, as these are the biggest proportion of all long-distance trips (Davis et al., 2018; LaMondia & Bhat, 2012). This will later be confirmed in the survey of this study, where 91% of the respondents who indicate to have travelled long-distance in the past year say it was mostly for leisure purposes. The respondents are also asked to imagine they are travelling alone, as this relieves them of any travel complications, only makes them consider their own preferences, and pushes them to rely only on their own knowledge and capabilities.

4.1.3. Attribute levels

This subsection explains the included attributes and corresponding levels. All attributes are varied on two, three or four levels. Table 4.1 provides an overview of the included attributes, their levels and the expected direction of the contribution to the utility. Thereafter, each attribute and its levels are clarified.

Table 4.1: Overview of attributes and levels

Attributes	Levels				Exp. utility contr.
Travel cost	€ 50	€ 70	€ 90	€ 110	Negative
Transfer time	5 min	20 min	35 min	50 min	non-linear
Travel time	8 hours	10 hours	12 hours		Negative
Number of transfers	1	2			Negative
Time distribution	Even (0)	Uneven long-short (1)	Uneven short-long (2)		Unknown
Service	Light (0)	Standard (1)	Premium (2)		Positive

Travel cost

The first attribute included in each alternative is the total travel cost. This attribute is important in determining the willingness to pay for all included factors. To create an accurate picture, the attribute levels are estimated based on the current costs of trips within the choice context. For example, when booking via NS International, a single ticket from Amsterdam Centraal to Munchen Hbf costs between 35 and 120 euros, depending on the chosen travel time and date. When booking via Treinreiswinkel, a single ticket from Amsterdam Centraal to Basel costs between 40 and 210 euros, with an average of around 70 euros. However, since the choices in the SC experiment are not dependent on the date or travel time, a wide range would not be a good reflection of reality. The attribute levels are set at €50, €70, €90, and €110 to keep it a fair choice that is not that easily dominated by cost.

Transfer time

The second included attribute is transfer time. From the focus groups, it was found that the transfer time contributes to the stress level of travellers. Several people in the focus group have indicated that the desired transfer time depends on other journey characteristics. As optimal transfer time for long-distance train journeys, some values between 15 and 60 minutes are mentioned. When looking up long-distance trips on booking sites such as NS International or Treinreiswinkel, transfer times typically range between 5 minutes and 60 minutes, or in a few cases even longer (mostly cases that include a high-speed train). The differences in transfer time are expected to weigh more heavily when considering cases below 60 minutes. To capture these realistic differences, the transfer time levels are set at 5, 20, 35, and 50 minutes.

Travel time

The total travel time of European examples of trips between 600 and 800 km varies. The cases of Amsterdam-Munchen, Amsterdam-Basel, and Amsterdam-Lyon were considered. The total travel time mostly ranges between 7 hours and 12 hours, as found on Dutch booking platforms like NS International and Treinreiswinkel. To make the alternatives easy to interpret, the total travel times are varied at 8 hours, 10 hours, and 12 hours.

Number of transfers

The number of transfers is varied at either 1 or 2 transfers. Considering the future plans of the European rail network, for example, the TEN-T network of the European Commission, these are realistic numbers. By varying this attribute at two levels, the alternatives are easy to interpret, while a trade-off between time or costs and the number of transfers can still be made by the respondents. Since the time distribution is also considered in the experiment, adding more transfers would make the alternatives too complicated.

Time distribution

This attribute indicates how the travel time is distributed over the several parts of a journey. When considering a journey with one transfer, this is the distribution of the time before and after the transfer. When considering a journey with two transfers, it is the distribution of the time before the first transfer, in between the two transfers, and after the second transfer. This attribute is varied over 3 nominal levels.

The first level (0) is an even distribution, which means that the travel time is the same for all parts of the journey. In cases with one transfer, the proportion division is $\frac{1}{2} - \frac{1}{2}$, and in cases with two transfers, the division is $\frac{1}{3} - \frac{1}{3} - \frac{1}{3}$.

The second level (1) is an uneven distribution with a longer time in the beginning and a shorter time at the end of the journey. This means that the longest part of the journey is in the beginning and that the transfer(s) occur(s) later in the journey. In cases with one transfer, the proportion division is $\frac{3}{4} - \frac{1}{4}$, and in cases with two transfers, the division is $\frac{2}{3} - \frac{1}{6} - \frac{1}{6}$.

The third level (2) is an uneven distribution with a shorter time in the beginning and a longer time in the journey. This means the longest part of the journey is at the end, and the transfer(s) occur(s) early. In cases with one transfer, the proportion division is $\frac{1}{4} - \frac{3}{4}$, and in cases with two transfers, the division is $\frac{1}{6} - \frac{1}{6} - \frac{2}{3}$.

For each combination of total travel time, number of transfers, and time distribution, a specific case is presented to the respondent. For example, a 12-hour journey with two transfers and an even time distribution is presented as three parts of each 4 hours. The same case with an uneven long-short distribution is presented as first a ride of 8 hours, and then two of 2 hours.

Service

Since lack of service is a frequently mentioned sore point of train travel as opposed to air travel in both the literature and the focus groups, it is included in the experiment via this attribute. The attribute is varied on three nominal levels. These levels are based on the service levels in air travel, as this comparison is often made. The three levels are called Light (0), Standard (1), and Premium (2), similar to the ticket options of KLM (KLM, n.d.).

The first level (0), Light, is the base alternative without any extra services. It appeals to the self-reliance of the traveller. This ticket is set for a certain day and time and that cannot be changed. If you miss your connection due to a delay or cancellation, you can use it for the next train but you will lose your assigned seat. Refunds are given per part of the journey, and will only be provided for the part of the trip that is directly affected by a delay or cancellation. The size of the refund will be scaled to the severity of the disruption. If you end up not using your ticket for a train without disruptions, you will not be able to get a refund. No alternative travel options will be offered by the operator.

The second level (1), Standard, is a mid-option. This ticket is set for a certain day and time and that cannot be changed. Refunds are given on a full-journey basis, for which the train operators of all parts of the journey are in an alliance. This means that full refunds can be given, even if not every part of the journey is affected by a disruption. If you miss your connection due to a delay or cancellation, you can use it for the next train but you will lose your assigned seat. No alternative travel options will be offered by the operator.

The third level (2), Premium, is the high-end option. You can change your ticket to another day or time without paying an extra fee and only pay the fare difference (if applicable). Refunds are given on a full-journey basis, for which the train operators of all parts of the journey are in an alliance. This means that full refunds can be given, even if not every part of the journey is affected by a disruption. If you miss your connection due to a delay or cancellation, the operator will offer an assigned seat on an alternative train.

The three alternatives are explained to the respondents with the overview in figure 4.1. For the Dutch translation, see the survey in appendix E.

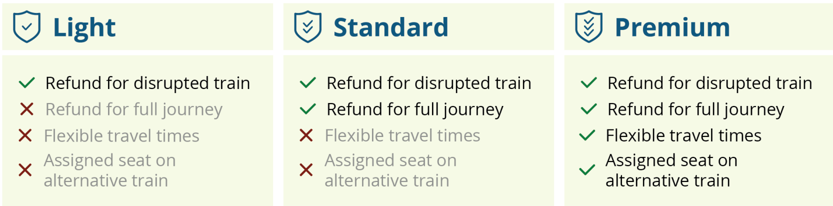


Figure 4.1: Overview of the service attribute

4.1.4. Alternatives and visualisation

The alternatives are unlabeled since they are all train journeys with the same attributes that vary on the same level. There are no characteristics that are not varied in the experiment (like mode). They are presented to the respondents as 'travel option 1', 'travel option 2' and 'travel option 3' (or 'Reisoptie' in Dutch). Each choice set contains three alternatives. To gain as much information as possible with 1 choice set and keep the required number of respondents low, the degree of freedom should be as high as possible, which asks for more alternatives in a choice set. However, a choice should not become complicated. Three alternatives per choice task were chosen to keep the choice clear and the alternatives easily comparable for the respondents.

A choice set is presented visually. An example of what this looks like is shown in figure 4.2.

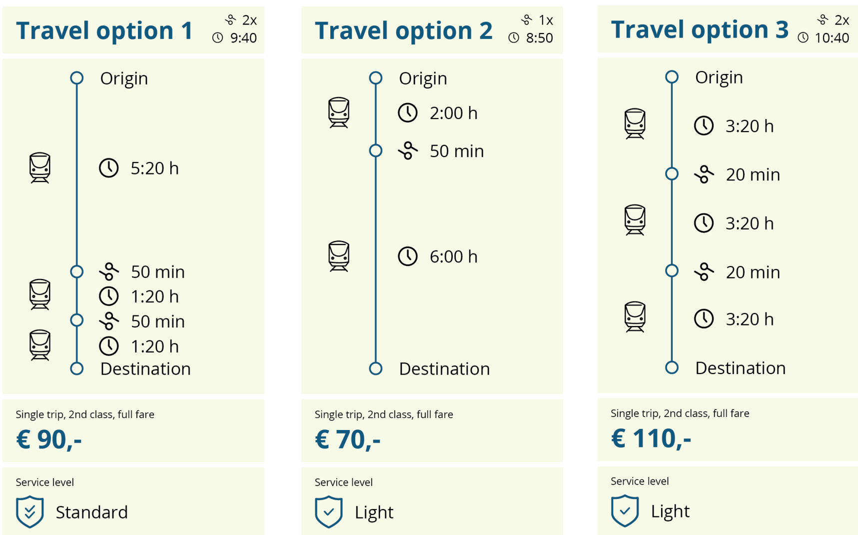


Figure 4.2: Example of a choice set

This design was based on the designs of the existing route planners of NS and 9292. It was designed in such a way that respondents will understand the alternatives easily, intuitively, and quickly. At the top, the respondents can see the number of transfers and the total travel time. On the left, the respondents see the train icons and can immediately see how many trains are included in the travel. The location of the transfers is visually reflected in the location of the dots on the long line. The travel and transfer times are provided next to the line. Below the journey, they see the travel costs and service level. Before the respondents are presented with the choice sets, all the visual aspects are highlighted and explained with an example alternative. This sequence of explanations is shown in figure 4.3.

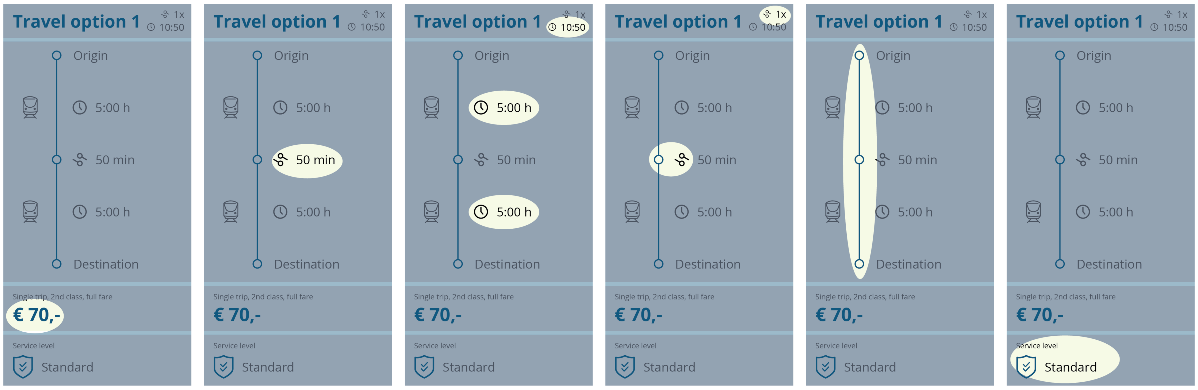


Figure 4.3: Sequence of explanations of different attribute levels

4.1.5. Base alternative and opt-out

As explained in the methodology, the respondent is also presented with a base alternative after they have made their choice. This base alternative is a direct connection and contains no transfers. Providing such a base alternative is important to maintain realistic options and allow respondents to contextualise their choices.

The underlying goal of this second choice task (transfer vs. no transfer) is to see if respondents would choose a 'good' transfer over a direct trip. With this choice task, they indicate whether the transfer trip they just chose is good enough to replace the direct trip presented in option 4. The attribute levels of the base alternative are fixed at the worst levels: 110 euros, 12 hours, and light service, so the chosen alternative can either score equal or better in several degrees, except for the number of transfers attribute. This allows us to see to what extent each of the three attributes contributes to a transfer being perceived as 'good', and how much better a travel option should score on these aspects to cancel out the transfer penalty. On top of that, since it is expected that a direct train will score better than a transfer alternative, by fixing the base alternative at these worst levels, it will not be dominant over the transfer options. Dominance would make it impossible to accurately estimate the corresponding parameters. This base alternative will be associated with an alternative specific constant (ASC) in the model. By comparing the ASC estimates of the different classes, you are able to tell which classes are more transfer-averse and which care less about transfers. A visualisation of what this base alternative looks like is shown in figure 4.4.

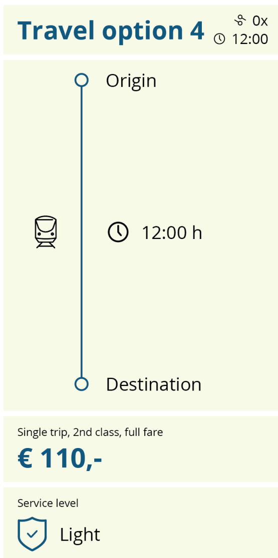


Figure 4.4: Base alternative

Finally, the respondents are asked for each choice situation if given all four travel options, they would choose to make this trip by train or opt for another mode like car or plane (opt-out). This question is included for multiple reasons. First of all, it will provide a complete picture of the choices. In real life, someone is always able to opt for another mode of transportation. Asking this question enables a respondent to contextualise their previously made choices. This question can identify respondents that are firm dislikers of trains. Someone who is intrinsically very opposed to train travel is also expected to make less rational choices when they are forced to choose between only train alternatives. Therefore, this is important information to be aware of. This question will also estimate an ASC for the opt-out. by comparing these estimates of the different classes of the LCCM, you can tell which classes are more opposed to train travel and which classes actually prefer train travel. These estimations can also be used to calculate hypothetical market shares of train travel versus other modes.

Each choice task is thus divided into three questions:

Question 1:	Choice between only the three transfer train alternatives
Question 2:	Choice between the selected transfer alternative and the transferless base alternative
Question 3:	Choice between any of the train alternatives or another mode (Opt-out)

This setup was chosen over presenting all five alternatives all at once because it is expected that the transferless and opt-out alternatives might be dominant over the transfer options. If this is the case and they are proposed in the same question, too little information will be gathered about the transfer attributes to make good parameter estimations, which is actually the main goal of this study. Therefore, the three-question approach was chosen. This approach will also help the respondent with consuming all the information. Having to choose between all five alternatives at once can be confusing, and separating it into three questions will make this more manageable and easier to understand.

4.1.6. Psychological factors

In the focus groups, it was found that choice behaviour might be influenced by psychological factors. In this section of the survey, respondents are asked for their rationale for making certain travel choices. Are they optimistic or sceptical towards train travel? Why? And how do they let this influence their choices? The respondents are presented with a series of statements, for which they have to indicate how much they agree with them on a 5-point Likert scale. These questions are asked after the choice experiment, as they might otherwise affect the respondent's intuitive choice-making. After performing a factor analysis to see whether the statements actually describe the latent factors, this data is incorporated into the model as covariates. Based on the literature research and the focus group outcomes, three psychological topics were selected to be incorporated into the experiment, as these seem to influence choice behaviour the most. These are:

- A respondent's intention to use environmentally friendly means of transportation.
- A respondent's personal liking of trains and travelling by train.
- The extent to which a respondent is driven by bad experiences with train travel.

For each topic, several statements are formulated to estimate these underlying psychological factors in a factor analysis. These are listed below.

Environmental considerations

1. I think it is important to use environmentally friendly means of transport, like the bicycle or train.
2. I use environmentally friendly means of transport, even if this means I have to make a less comfortable or convenient journey.
3. I believe that individual actions, like choosing environmentally friendly transportation, can make a difference in addressing climate change.
4. I actively seek out environmentally friendly transportation options in my daily life.

Personal liking of trains and travelling by train

1. I find train journeys to be relaxing and enjoyable.
2. I have a strong affinity for trains and train-related experiences.
3. I enjoy the scenic views and landscapes that train travel offers.
4. I feel a sense of excitement or adventure when embarking on a train journey.

Bad experience with train travel

1. I have had a bad experience on a long-distance train journey.
2. In general, I often have bad experiences when travelling by train.
3. If I have had a bad experience with long-distance train travel, I am unlikely to choose the train again next time.
4. I expect there will be a disruption if I choose to travel by train over long distances.

4.1.7. Socio-demographics

The socio-demographic characteristics of the respondents are used in the class-membership model of the LCCM. The socio-demographics might correlate with certain choices. A chance for a respondent to be in a certain class can be estimated based on the socio-demographics. The socio-demographic variables make each class easy to interpret. The following variables are included in this study: Age, Gender, Employment status, Education, Province of residence, Income, and Car ownership. The questions about socio-demographics are easy to answer and are therefore a good conclusion to the survey. The socio-demographic questions are also multiple-choice. Some of these questions include ranges (like income ranges) to preserve the anonymity of the respondents and simplify the data output.

4.2. Survey construction

This section describes how the survey was constructed. The whole survey can be found in appendix E. Note that this survey is in Dutch as it is distributed among Dutch respondents.

4.2.1. Choice set generation

With the attributes and levels that were defined, the choice sets could be generated. This was done with the Ngene software package. The Ngene code for generating the choice sets can be found in appendix D. The code defines three unlabeled alternatives that have the same utility functions. The design requires 36 rows, meaning 36 choice sets. This was found by Ngene after trying a lower number of rows. Since 36 choice sets are way too many to present to one respondent, Ngene is asked to create 4 blocks by adding a free column to the design. By adding a free row, there is also orthogonality and attribute level balance within each block. This separates the choice sets into four parts, meaning there are four versions of the survey and each respondent only makes 9 of the 36 choices. The orthogonal design is sequentially constructed because the alternatives are unlabeled. The model states that the utility of each attribute is derived from a sum of each attribute level multiplied by the corresponding attribute parameters.

Because the directions of four of the attributes are evident, we can check for dominance within the choice sets. If one alternative in the choice set performs better on all of those four attributes than another alternative, this alternative might be dominant. With a choice set of 3 attributes, this can occur 3 times (1 vs 2, 2 vs 3, and 1 vs 3). However, since the other two attributes do not have a clear direction, this is not necessarily the case. We want to find a set of choice tasks in which the risk of dominance is as low as possible. Since Ngene includes a random factor in the choice set construction, each run will result in different choice sets. A series of runs were performed to find a set of choice sets that had the least dominance within the directed attributes. A set was found in which the dominance risk occurred only 18 of the 108 (3x36) times, and there was never a strictly dominant choice set in which one alternative was better than the second and the second was better than the third. This run was therefore selected to be in the survey. Respondents of the pilot survey were asked to indicate if they found one of the alternatives to be dominant over another. This was always either not the case or relative to personal preferences.

4.2.2. Pilot survey

A pilot survey of the first draft was sent out to be tested before the actual survey was distributed. This was done amongst the personal circles of the researcher. The pilot survey had three main goals.

1. Making sure the survey is clear. The explanations should be understandable and it should be clear what is being asked. This was measured by incorporating extra questions asking for feedback.
2. Check for dominance in choice sets. After each choice set, the respondents of the pilot survey

were asked if they found the choice to be easy or hard, and if they felt one of the alternatives was dominant over another.

3. Check attribute levels. The attribute levels should be varied wide enough to differentiate the alternatives, but not too wide, allowing for one attribute to be very dominant over the others. Participants were asked for feedback about this in separate questions.

The results of the pilot survey have already been processed in the design as it is reported in this research. The main changes were:

- Bring clarity to whether 'trip' means a single trip or a return trip.
- Make the font size of the price smaller, as it looks more important than other attributes.
- Add labels to the service levels, so easier to understand.
- Add the total travel time to the visualisation.
- The travel cost of the base alternative was first fixed at €150, but this difference with a €50 euros alternative is too high. It should also be within the level range. Therefore it was set at the highest level, €110.

5 Data

This chapter first describes how the data is gathered, what the required number of respondents is and what the data sample looks like. Thereafter, it explains how the raw data from the survey is processed into a usable data file for the model. Finally, this chapter will elaborate on some of the specifications of the model.

5.1. Data gathering

The survey is distributed amongst the population. This is done via the NS panel, which is arranged by RHDHV. The NS panel is a large group of people who volunteered to participate in research like this one. Using the NS panel as population sample comes with several benefits. First of all, the number of respondents is significantly higher, which increases the statistical significance of the results. Also, in the NS panel are many people who are familiar with the network and may have knowledge of affairs. You can easily target frequent users. However, the NS panel can also come with a response bias, as the NS panel might not be a good representation of the average long-distance traveller. This should be clearly mentioned as a limitation of the project. But all in all, it gives much more reliable results than the alternative, which is distributing the survey via the researcher's personal connections.

The programming of the survey is done by MWM2, a large market research firm, which also manages the survey distribution and data collection. Some minor changes are made to the survey design in appendix E. For example, in the NS Panel, it is customary to use an informal address (tutoyer) instead of a formal address (vousvoyer). MWM2 adapted the formulation of the questions accordingly. Also, some of the sociodemographic variables are already known by NS panel members and therefore do not have to be included in the survey. This includes age, gender, train usage, education and work status. Screenshots of the web version of the survey, the way it was shown to respondents, can be found in appendix F.

5.1.1. Number of respondents

To derive significant parameters from the choice model, the number of respondents should be as high as possible. Orme (2010) has provided an equation that can estimate the minimum number of respondents necessary in the sample to achieve significant results. It is formulated in equation 5.1.

$$\frac{n \cdot t \cdot a}{c} \geq 500 \tag{5.1}$$

In this formula, n is the number of respondents, t is the number of choice tasks, a is the number of alternatives in each choice task, and c is the highest number of attribute levels that are featured in the survey. So when you rewrite this formula, you can calculate the required number of respondents per block. Since there are 4 blocks, you have to multiply this number by 4.

$$\begin{aligned} n_{block} &\geq \frac{500 \cdot c}{t \cdot a} = \frac{500 \cdot 4}{9 \cdot 3} = 74,07... \approx 75 \\ n_{total} &= 75 \cdot 4 = 300 \end{aligned} \tag{5.2}$$

As is shown in equation 5.2, 300 respondents are needed. This number is quite high, but since the survey is distributed via the NS panel, very possible to obtain.

5.1.2. Data sample

The survey was available for 8 days, and all invitees who did not fill it in within 4 days received a reminder e-mail. Unfortunately, the number of dropouts was relatively high. Most dropouts quit after opening the explanation page. This is taken into account in the recommendations for future research. The survey was completed by 431 respondents.

The survey is programmed in such a way that respondents are automatically assigned to one of the blocks. MWM2 also made sure that the sample is a representative distribution of the Dutch population in terms of sociodemographic variables. In the table 5.1, the data sample is shown in terms of socio-demographics.

Some of the collected data in this table is aggregated, and also used aggregated in the coding of the model. How this is done is explained in section 5.2.2.

Some socio-demographic data is unknown. The income question is the only question where respondents could indicate that they would rather not answer, which led to 88 unknowns. The other unknowns in the dataset come from flaws in the NS panel respondent data.

Table 5.1: Data Sample

Socio-demographic	Category	Number	Percentage
Gender	Female	193	44,8%
	Male	230	53,4%
	Other	7	1,6%
	Unknown	1	0,2%
	Total	*431*	*100,0%*
Age	18-24	32	7,4%
	25-34	84	19,5%
	35-44	49	11,4%
	45-54	115	26,7%
	55-64	55	12,8%
	65-74	96	22,3%
	Total	*431*	*100,0%*
Employment status	Working	288	66,8%
	Student	33	7,7%
	Retired	54	12,5%
	Other	25	5,8%
	Unknown	31	7,2%
	Total	*431*	*100,0%*
Education	Low	116	26,9%
	High	310	71,9%
	Unknown	5	1,2%
	Total	*431*	*100,0%*
Province of residence	Randstad	239	55,5%
	Other	192	44,5%
	Total	*431*	*100,0%*
Income	Low	74	17,2%
	Mid	188	43,6%
	High	81	18,8%
	Unknown	88	20,4%
	Total	*431*	*100,0%*
Car ownership	0	179	41,5%
	1	207	48,0%
	2	40	9,3%
	3+	5	1,2%
	Total	*431*	*100,0%*

5.2. Data processing

Next, the processing of the data from the survey is done. First, it is explained how the factor analysis on the psychological factors is performed and how these are incorporated into the dataset. Next, the coding of all other elements in the survey is explained.

5.2.1. Factor analysis

By performing a factor analysis, we want to see if, and how, items load together on the three latent factors as defined in section 4.1.6. For each factor, 4 statements were drawn up which respondents had to rate on a scale from 1 (Completely disagree) to 5 (Completely agree). The factor analysis is performed in SPSS. SPSS is also asked to save the factor scores as variables to the data file, using regression as the method. These are scores per factor per respondent that identify on what side of the spectrum the respondent is for each factor, for example, if someone had a very high intention to use environmentally friendly modes or not as opposed to the other respondents. These scores are normally distributed around 0. In tables 5.2 and 5.3, the pattern matrix and factor correlation matrix are shown.

Table 5.2: Pattern matrix

	Factor 1	Factor 2	Factor 3
environment1	0,844		
environment2	0,815		
environment3	0,616		
environment4	0,900		
experience1		0,523	
experience2		0,638	
experience3		0,355	
experience4		0,658	
liking1			0,694
liking2			0,746
liking3			0,623
liking4			0,696

Table 5.3: Factor correlation matrix

	Factor 1	Factor 2	Factor 3
Factor 1	1,000	-0,005	0,499
Factor 2	-0,005	1,000	-0,206
Factor 3	0,499	-0,206	1,000

In table 5.2, it is shown that SPSS finds 3 factors. Each factor is described by four items, which for each factor are items that belong together. This indicates that the four drawn-up statements indeed describe the factors, as the table shows that all statements on the same topic are assigned to the same factor. Most of the values in the pattern matrix are quite high, which means the items describe the factors very well. Only the item named 'experience3' which is the item associated with the statement 'If I have had a bad experience with long-distance train travel, I am unlikely to choose the train again next time.' is below 0.5, which means this indicator is not very good. Therefore, the reliability can be assessed. A reliability test was performed, and can be found in appendix G. Here, it was found that this item does not make the factor less reliable. However, it has a questionable internal consistency. Results regarding this factor should thus be interpreted cautiously.

In the correlation matrix in table 5.3, you can see the correlations between the different factors. It is visible that factors 1 (Environmental considerations) and 2 (Bad experience with (long-distance) train travel) are almost uncorrelated, with a correlation of -0.005. Factor 1 and 3 (Personal liking of trains and travelling by trains) are most correlated, with a value of 0.499. This means that people who have the intention to use environmentally friendly modes are likely to also have a personal liking for trains and travelling by trains and vice versa. Factors 2 and 3 are slightly correlated with a value of -0.206, indicating that people who have bad experience with train travel can also have a personal dislike for trains and train travel, or people with good experience like train travel better. These correlations are logical and explainable.

To conclude the factor analysis, it was proven that the four statements of each factor indeed load together on the latent factors. The factor scores can therefore be included as covariates in the LCCM as they indicate a respondent's intention to use environmentally friendly modes, the extent to which they are influenced by negative experiences, and the respondent's personal liking for trains and travelling by train.

5.2.2. Naming and coding

Table 5.4 indicates the naming of all attributes, covariates, and levels, like they were used in the data set.

Table 5.4: Naming

Main attributes	
Travel cost	cost
€ 50	0.5
€ 70	0.7
€ 90	0.9
€ 110	1.1
Transfer time	transfertime
5 min	0.0833
20 min	0.3333
35 min	0.5833
50 min	0.8333
Squared transfer time	sq_transfertime
5 min	0.0069
20 min	0.1111
35 min	0.3402
50 min	0.6944
Travel time	traveltime
8 hours	0.8
10 hours	1
12 hours	1.2
Number of transfers	numberoftransfers
1 transfer	1
2 transfers	2
Time distribution	distribution
Even	even
Uneven long-short	unevenLS
Uneven short-long	unevenSL
Service	service
Light	light
Standard	standard
Premium	premium
ASC for transferless option	notransfer
ASC for opt-out option	nopick

Factors	
Environmental considerations	ENVIRONMENT
Factor scores	$\sim \mathcal{N}(0,1)$
Personal liking of trains and train travel	LIKING
Factor scores	$\sim \mathcal{N}(0,1)$
Bad experience with (LD)train travel	EXPERIENCE
Factor scores	$\sim \mathcal{N}(0,1)$

Socio-demographics	
Gender	GENDER
Female	Female
Male and other	Other
Age	AGE
Age in years	Numeric age
Education	EDUCATION
Lower than HBO bachelor	Low
HBO bachelor or higher	High
Workstatus	WORKSTATUS
Working	Working
Student	Student
Retired	Retired
Other	Other
Income	INCOME
Les than 30.000	Low
30.000-70.000	Mid
70.000 or more	High
Province of residence	PROVICE
N-Holland, Z-Holland or Utrecht	Randstad
Other	Other
Car ownership	CARS
No cars available	No
1 or more cars available	Yes

Train usage	
Train use frequency	TRAINUSE
Once a week or more	Often
Other	Seldom
Long-distance travel frequency	LD_TRAVEL
3 times or more	Often
Other	Seldom
Long-distance train travel	LD_TRAIN
1 time or more	Yes
Other	Never
Main travel motive	MOTIVE
Business	Business
Leisure	Leisure
Main travel company	COMPANY
Alone	Alone
With partner	Partner
Other	Other

The left column denotes the variable name and input from the survey, and the right column denotes how the variables are called in the dataset and model and how different levels are coded. It also indicates how the Alternative Specific Constants (ASC) were coded for the transferless and opt-out options. Alterations to the initial data file were made in Python with Pandas. Since the model estimation is done in LatentGOLD, the nominal variables are effects coded, since this is default in the software. Effects coding selects one nominal level which is coded -1 on all indicators. This leads to the utility contributions of all levels summing up to 0, and the average contribution is also 0. The software randomly selects one of the levels to be coded as -1 and estimates the parameters. The software iterates this process over all levels to obtain a significance for each level.

The utility of each alternative can be calculated with equation 5.3. Note that for the time distribution and service parameters, the subscript indicates the nominal level, and that each β is the negative sum of the βs of the other two levels. In the LCCM model, all β values are class-dependent.

$$
\begin{aligned}
U\left(ALT_{transfer}\right) = \ & \beta_{cost} \cdot cost \ + \\
& \beta_{transfertime} \cdot transfertime \ + \\
& \beta_{sq\_transfertime} \cdot transfertime^2 \ + \\
& \beta_{traveltime} \cdot traveltime \ + \\
& \beta_{numberoftransfers} \cdot numberoftransfers \ + \\
& \beta_{distribution_{even}} \cdot distibution_{even} \ + \\
& \beta_{distribution_{unevenLS}} \cdot distribution_{unevenLS} \ + \\
& \beta_{distribution_{unevenSL}} \cdot distribution_{unevenSL} \ + \\
& \beta_{service_{light}} \cdot service_{light} \ + \\
& \beta_{service_{standard}} \cdot service_{standard} \ + \\
& \beta_{service_{premium}} \cdot service_{premium} \\
U\left(ALT_{base}\right) = \ & \beta_{cost} \cdot cost_{base} \ + \\
& \beta_{traveltime} \cdot traveltime_{base} \ + \\
& \beta_{service_{light}} \cdot service_{light,base} \ + \\
& \beta_{service_{standard}} \cdot service_{standard,base} \ + \\
& \beta_{service_{premium}} \cdot service_{premium,base} \ + \\
& notransfer \\
U(optout) = \ & nopick
\end{aligned}
\tag{5.3}
$$

As can be seen in table 5.4, some of the numeric variables are scaled. This is done to keep them in the same order of magnitude, making the beta estimates easier to compare and ensuring that they do not differ too much in terms of order of magnitude. The travel cost has been scaled by a factor of 100, the transfer time has been converted from minutes to hours (factor of 60), and the travel time has been scaled by a factor of 10. This has no further effect on the results, but makes calculations easier and no results will be lost due to rounding.

Some of the nominal variables were aggregated into larger groups. All these aggregations are shown in the socio-demographics part in table 5.4, but are now explained once more for clarification. Employment status was aggregated to 'working', meaning full-time or part-time employed, 'student', 'retired', and 'other'. The latter includes people who are unemployed, unable to work, volunteers, etc. Education was split into 'High' and 'Low'. A respondent is labelled highly educated when they have an HBO bachelor's degree or higher. Province of residence is split into 'Randstad' and 'Other'. Formally, the provinces belonging to the Randstad are Noord-Holland, Zuid-Holland, Utrecht, and Flevoland, but since the purpose of this variable is to see if people live near international railway stations, Flevoland was not included in the 'Randstad' label. Income is split into 'Low', 'Mid', and 'High incomes. A respondent receives the label 'low' income when they earn less than the Dutch average income, which is defined as less than €30.000 gross per year. A respondent receives the label 'mid' income when they earn something between the Dutch average income and twice the Dutch average income, which is defined as between €30.000 and €70.000 gross per year. A respondent with an income of above €70.000 is labelled 'high'. Car ownership was split into people who do and do not own one or more cars. A respondent who travels by train once a week or more is considered to use the train often, all others are considered to use the train seldom. Someone who has travelled long-distance 3 times or more in the past year is considered to travel long-distance often, the rest is considered to travel seldom. 'LD_TRAIN' indicates if someone travelled by train over long distances in the past year or not.

All missing values are coded as "." and defined as such in the SPSS files that are used as input for latent gold. The missing values include unknown data on socio-demographics where only a few data points were missing (gender, train use, and education). For socio-demographics where more data was missing, 'Unknown' was included as a separate level (income and work status). Other 'missing' values are for example when a respondent indicated not to have travelled long-distance over the past year, they are also not asked about their long-distance train travel over the past year, travel company, and motive for those trips. Also in the base and opt-out alternatives, attributes that are not included in the utility function are coded as missing values.

5.3. Model specification

Initially, and based on the question structure of the survey, three separate experiments were considered.

Experiment 1:	Only transfer alternatives (3 alternatives)
Experiment 2:	Transfer alternatives and transferless base alternative (4 alternatives)
Experiment 3:	Transfer alternatives, transferless base alternative, and opt-out (5 alternatives)

In the second experiment, the transferless base alternative was chosen 764 times (19,7%) over the initial choice. In the third experiment, the opt-out was chosen 652 times (16,8%) of which 475 times over the initial transfer choice and 177 times over the transferless base alternative. This means that in the third experiment, a transfer choice was chosen 2640 times (68,1%) and the base alternative 587 times (15,1%). By modelling all three experiments, it was found that the parameter estimates of the MNL models were very similar, indicating that the third experiment still contains enough information about the transfer attributes to make correct parameter estimates. Therefore, it was chosen to only consider the model of the rest of this research as it contains the most comprehensive and the most reliable information. The model is estimated with a regular MNL model and an LCCM.

Latent GOLD is used to estimate both the MNL model, using a 1-class LCCM, and the LCCM. The Latent GOLD setup can be found in appendix H.

5.3.1. MNL specification

The first type of model that is estimated is a Multinomial Logit (MNL) model. This is a relatively simple and straightforward model, which serves as the foundation of the LCCM. Essentially, an MNL model represents an LCCM with a single class. The MNL model does not account for heterogeneity within the population. Nevertheless, it is interesting to estimate since it provides the population's average estimates. It also has widespread usage and fast computational time.

Non-linearity is assumed for the transfer time attribute. Therefore, a quadratic component was added to the attributes and the utility functions. These levels are also shown in table 5.4. By adding this component, you can compare both approaches (linear and non-linear) to see whether the utility contribution direction is constant or not. It was found that the quadratic component was statistically significant. The utility contributions of all transfer time levels from the linear approach and the non-linear approach were compared, and a significant difference was found, indicating an impact of the quadratic component. Therefore, it was decided to code the transfer time quadratically. The nominal attributes (distribution and service) were effects coded, meaning the parameter estimate of each level is the negative sum of the parameter estimates of the other two levels. Effects coding is the default setting for nominal variables in Latent GOLD.

5.3.2. LCCM specification

The LCCM was estimated using the 1-file format in Latent GOLD Choice. The alternative is a 3-file format (Default), where the responses, alternatives, and choice sets are described in different files. In the 1-file format, this information is put together in a single file. The 1-file format was chosen since it felt more intuitive to use and a clear tutorial was available. The model setup can be found in appendix H.

When estimating an MNL model, the log-likelihood (LL) function is concave, meaning there is one optimum to be found. Since an LCCM includes a class-membership function and builds a model of different MNLs, it results in a non-concave LL function (Hernandez, 2023). Picking starting values when estimating an LCCM is therefore crucial, as the estimation can get stuck in local optima. To handle this as effectively as possible, in the 'Technical' tab of the model setup, under 'Start values', the number of random sets has been set to 200. This means that 200 random sets of starting values are selected and applied to the model estimation, after which the candidate with the highest LL is chosen after 50 iterations. Latent GOLD can do this faster than other software programs.

Furthermore, the number of classes in the LCCM needs to be determined. This is done with the Bayesian Information Criterion (BIC) value. A lower BIC value is preferred, as this optimises the balance between a good LL and a low number of parameters. Latent GOLD is asked to estimate the models of 1 to 6 classes. The LLs and BICs for each model are shown in table 5.5. The maximum LL increases when a latent class is added to the model, but the BIC has an optimum with 5 classes, indicated in bold in the green cell. However, a lower number of classes can be chosen if an additional class does not improve the model's interpretability. In this instance, the fifth class does not add to the analytical insights, and thus, the 4-class model is interpreted.

Table 5.5: LL and BIC for different amounts of classes

Model	LL	BIC(LL)
1-Class	-5265,6289	10597,9849
2-Class	-4275,7651	8806,3068
3-Class	-3902,9616	8248,7491
4-Class	-3777,3694	8222,0108
5-Class	-3660,8037	**8189,0610**
6-Class	-3581,2491	8230,1332

6

Results

This chapter aims to answer the research questions by analysing the model output. It first dives into the average travel behaviour of the population by analysing the MNL model. Then, different classes with different behavioural patterns are distinguished and analysed with the LCCM.

6.1. MNL results

First, the results of the MNL model (1-class LCCM) are discussed. These results represent the sample's average as every respondent is included in a single class. The overall ρ^2 of this model is 0.1313. This is a measure of the model's goodness-of-fit based on the ratio between the likelihood of the estimated model and the likelihood of a model with no explanatory variables. A higher ρ^2 value indicates a better model fit. For an MNL, 0.1313 indicates a reasonable model fit.

6.1.1. Parameter estimates

Table 6.1 shows the average parameter estimates for each attribute. The z-value in the column on the right denotes the significance of the parameter and can be interpreted as the t-statistic. This means an estimate is statistically significant when the absolute value is larger than 1.96. All estimates that are statistically significant are marked green and bold.

Table 6.1: Average estimates MNL

Attributes		Estimate	z-value
cost		**-3,70**	-21,83
transfertime		**4,77**	9,55
sq_transfertime		**-4,57**	-8,77
traveltime		**-4,29**	-25,62
numberoftransfers		**-1,10**	-21,26
distribution	even	0,01	0,14
	unevenLS	-0,03	-0,89
	unevenSL	0,03	0,76
service	light	**-0,21**	-5,89
	standard	0,01	0,13
	premium	**0,21**	5,71
notransfer		**1,31**	8,02
nopick		**-8,01**	-34,41

Note that a significance level is given for all levels of the nominal attributes. This is because the used software (Latent GOLD) estimates the model multiple times, picking another level as the reference level. You might notice that the z-value of each level is approximately the negative sum of the other two z-values, similar to the estimate of each level being the negative sum of the other level's estimates. This is because the standard error of different levels of the same variable is very similar when the group size is the same, which is guaranteed by the choice task design. Since the z-value represents the estimate divided by the standard error, and the standard errors are very similar, the z-values should be almost the sum of the other two, just like the estimates.

We see that the parameter estimates of the costs, the transfer time, the quadratic component of transfer time, the travel time, and the number of transfers are all statistically significant, which means that the respondents considered these factors when making the choice. Regarding the parameter estimates, the following observations can be made:

The parameter estimate for **travel cost** is negative, which means that higher costs make an alternative less attractive when all other attributes stay the same.

The parameter estimate of **transfer time** is positive, and its quadratic factor is negative. This means that when looking at low transfer times, a higher transfer time makes the alternative more attractive, but when looking at higher transfer times, the increase in attractiveness will deflect and at some point, it will even decrease. With these estimates, and considering only the attribute levels in the experiments, a transfer time of 35 minutes has the highest utility contribution and is thus generally considered the most favourable. You can also plot it in a graph, which results in figure 6.1. Not considering only the levels included in the study but all possible values, it becomes clear that a transfer time of 0.52 hours results in the highest utility contribution and is therefore generally the most optimal transfer time. Converted to minutes and seconds, that amounts to 31 minutes and 12 seconds. This is a very precise transfer time, but it is important to note that it is based on estimations, and therefore should be approached as around 31 minutes.

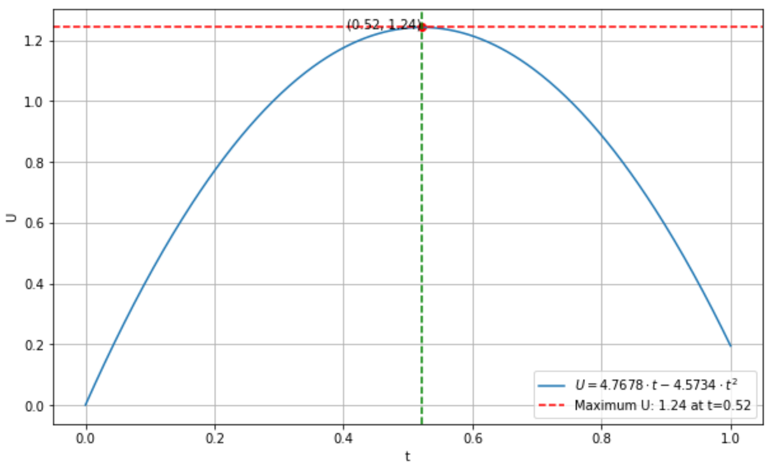


Figure 6.1: Utility contribution of transfer time plotted

The parameter estimate of **travel time** is negative, indicating that shorter journeys are generally preferred over longer ones.

The parameter estimate of the **number of transfers** is negative, meaning a journey is more attractive when it has one transfer rather than two transfers.

The parameter estimates of all levels of the **time distribution** are not significant. This means that there is insufficient evidence to conclude that the parameter is different from zero, and therefore does not have a significant effect on the choice probabilities. This indicates that the respondents generally are indifferent to this attribute and time distribution does generally not affect the travel choice.

The parameter estimates of **service** levels 'light' and 'premium' are statistically significant, while the parameter of level 'standard' is not. Since this attribute is effects coded, the sum of the utility contributions of the attribute levels is equal to zero, and one indicates the difference from the mean of the three. This means that an insignificant parameter does not differ from the mean utility contribution. This indicates that when the service level of an alternative is 'standard', it has an average effect on the attractiveness. This is not surprising as it is the average level. However, when the level is 'light' or 'premium', it has a negative or positive effect. The estimate of service level 'light' is negative, meaning that it decreases the attractiveness of an alternative, while the parameter estimate of service level 'premium' is positive and therefore increases an alternative's attractiveness.

'notransfer' denotes the ASC of the transferless base alternative. This estimate is significant and positive. In a labelled experiment where each alternative is associated with the same attributes, this ASC denotes the base preference for an alternative. This captures the differences in perceptions of the two alternatives. However, since the attributes of the base alternative in this study are not the same as those of the transfer alternative, the ASC cannot directly be interpreted as the base preference for a direct train. The constant represents the utility of the base alternative in the hypothetical situation where all attributes have a value of 0. However, this base alternative is special in the sense that it is also a train alternative, and it has fixed levels for its attributes. This means that the ASC can be corrected for these values. It is associated with a travel cost of €110, a travel time of 12 hours and a light service level. When you correct the ASC of 1,31 for these values, it results in a fixed utility of -8,11. Since the transfer alternatives are not associated with a constant, meaning it has a fixed constant of 0, this -8,11 is now the utility difference of transfer train trips compared to a comparable direct train trip (so with equal attribute levels). The negative systematic utility difference suggests that a base preference for direct trains exists. This captures the difference in perception, meaning that people generally perceive direct train trips better than transfer train trips.

Finally, there is the ASC for the opt-out alternative, **'nopick'**. The ASC is statistically significant and negative. Again, it cannot directly be interpreted as the base preference for another mode, since it does not have the same attributes. Although all attributes of the other mode alternative are fixed at 0 (or rather, not specified), this does not mean that the real-life attributes associated with other modes have the value 0. Respondents will likely take another mode in mind that they use often, like for example their car or a plane. These alternative also have travel time, travel cost, service level, etc. However, these values are unknown and cannot be corrected for. As the utility function of the opt-out alternative consists only of this constant, this means it is preferred over another alternative if the utility is lower than this value. For the MNL model, this ASC is not very insightful. However, when several classes are specified in the LCCM, the comparison of the ASC values can lead to insights on whether a class is more or less quick to choose the base alternative or opt-out, indicating if they are more or less likely to choose transfer options or train options in general than other classes.

6.1.2. Average importance of attributes

Now that the direction and effects of the average estimates are known, the average relative importance of the attributes is explored. For this, we consider the minimum and maximum utility contribution of each level given the parameter estimates and the attribute levels included in this experiment. The ASCs are not included in this analysis as they capture the baseline preference for each alternative that is not explained by the attributes included in the study. The goal here is to focus on the attributes, how they relate to each other, and understand how changes in these attributes impact choice probabilities. Table 6.2 presents for each attribute the minimum and maximum utility contribution, of which the absolute difference is the maximum utility difference. These differences are scaled to a relative importance in the right column. It is important to note that this relative importance is not absolute but also relative to the selected attribute level variance in this experiment. A smaller variance in attribute levels would automatically lead to a smaller utility difference, and a lesser importance. Yet, these values are presented since the level variance in the experiment is based on real-life examples. Still, it is important to keep this in mind.

Table 6.2: Maximum utility differences and relative importance of attributes

Attribute	Min. utility contribution	Max. utility contribution	Max. utility difference	Relative importance
Travel cost	-4,07	-1,85	2,22	35%
Transfer time	0,37	1,23	0,86	13%
Travel time	-5,14	-3,43	1,71	27%
Number of transfers	-2,20	-1,10	1,10	17%
Time distribution	-0,03	0,03	0,06	1%
Service	-0,21	0,21	0,42	7%

From this analysis, it becomes clear that on average, the most important attribute is cost, which is considered twice as important as the number of transfers, and a little more than two and a half times as important as transfer time. The next most important factor is travel time, which is considered a little less important than cost but overall still very important. The service level, unlike air travel as was found in section 3.1.3, is not considered very important. With a relative importance of 7% it is only half as important as transfer time, less than half as important as the number of transfers, a quarter as important as travel time and only a fifth as important as cost. Time distribution is considered to be very unimportant. It is important to note that all these results are on average.

6.1.3. Average willingness to pay

For each level increase of each attribute, a willingness to pay (WTP) can be calculated. Table 6.3 shows what the WTP is for each level increase. This is an average WTP over the entire population. The WTPs were calculated based on the utility difference of a level increase in the cost attribute. A €20 difference corresponds with a utility difference of 0,74. This means that people are on average willing to pay €27,04 for an increase of one 'util', which was used to calculate the WTPs.

Table 6.3: WTP for attribute level increases

Attribute	Level increase	Utility difference	WTP
Transfer time	5 - 20 min	0,72	€ 19,35
	20 - 35 min	0,14	€ 3,89
	35 - 50 min	-0,43	€ -11,57
Travel time	+ 2 hours	-0,86	€ -23,18
Number of transfers	1 - 2	-1,10	€ -29,75
Time distribution	unevenLS - even	0,04	€ 1,03
	even - unevenSL	0,02	€ 0,60
Service	light - standard	0,22	€ 5,87
	standard - premium	0,20	€ 5,47

From the results in table 6.3, it can be concluded that people are willing to pay €23,18 if they save two hours of travel time. This amounts to a Value of Time (VoT) of €11,59 per hour. The Dutch government estimated the VoT in 2022 to be about €11,50 for commuters, €22,30 for business trips, and €9,60 for other travel purposes (such as leisure) (Ministerie van Infrastructuur en Waterstaat, 2024). These numbers correspond to the found VoT. Looking at the VoT for specifically long-distance train travel, Wardman et al. (2016) calculated VoTs for each European country. They estimate the Dutch VoT for long-distance train travel to be €33,99. This is almost three times higher than the found VoT.

Another interesting result is that the average WTP for one transfer instead of two transfers is almost €30. This is quite a substantial share considering the price magnitude being considered in this study. Since the VoT is €11,59 per hour, you could also say that an extra transfer (2 transfers instead of 1) resembles a little over 2,5 hours of additional travel time. If the utility of the base alternative is compared to the utility of a similar alternative (same cost, time, and service) alternative with 1 transfer of 35 minutes (most optimal level), it results in a utility difference of 1.18. This translates to a WTP of €32,14 on average to make a direct trip instead of a trip with a single transfer, corresponding to an additional travel time of approximately 2 hours and 45 minutes. A first additional transfer thus has a bit higher impact on the attractiveness of a journey than a second additional transfer.

Other findings are that people are on average willing to pay only €11,34 for an upgrade from service level light to service level premium. This is a lot lower than expected based on the results of the literature research and focus groups. This WTP corresponds to an additional travel time of almost one hour.

6.2. LCCM results

Now that we know how the population behaves on average, it is interesting to distinguish different classes within the population of people exhibiting the same behaviour and to analyse the differences between these classes. Therefore, a latent class choice model is performed. As explained in the model specification, the population is split into 4 classes. The overall ρ^2 of the 4-class model is 0.4421, which is a very good fit. The found classes are graphically represented in figure 6.2.

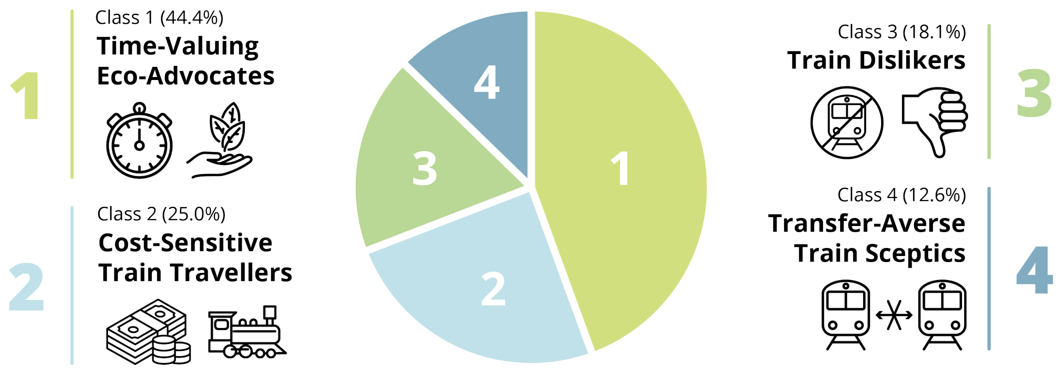


Figure 6.2: Latent Classes

First, the four classes are summarized in a class description. Next, we take a step back and the parameter estimates of each class are presented, analysed, and compared. Finally, the importance of attributes is covered, after which we elaborate on the willingness to pay per class.

6.2.1. Class descriptions

Class 1: Time-valuing eco-advocates (44.4%)
Class 1 is the largest class in the sample and is characterised by its high VoT. They prefer to arrive at their destination quickly. They are also sensitive to transfer time and the optimal transfer time lies around 33 minutes. However, they prefer to avoid this since they are somewhat transfer-averse. Someone who has a high intention to use environmentally friendly modes is more likely to belong to this class. Since this is the largest class, the population sample (the NS panel) contains a lot of environmentally conscious people.

Class 2: Cost-sensitive train travellers (25.0%)
Above all else, class 2 is very driven by costs. They are willing to compromise on a lot of fronts if it means they can reduce the costs of the travel. They are not time-sensitive, nor are they very opposed to making a transfer. However, they do like to travel by train and will not quickly choose another mode of transportation. Someone who is not driven by bad experiences with train travel is more likely to belong to this class. Also, in line with their cost sensitivity, people with lower incomes are more likely to belong to this class. Class 2 is the second largest class and accounts for about a quarter of the population sample.

Class 3: Train dislikers (18.1%)
A significant portion of respondents from the NS panel are not big fans of long-distance train travel, and express their criticism. Class 3 accounts for over 18% of the population sample. They are likely to be indifferent to the number of transfers and transfer time, but value a good service. This aligns with the finding that they are most likely to opt for another mode over train travel. A person is likely to belong to this class when they have often travelled over long distances in the past year, but never by train. They are likely to have no intention to use environmentally friendly modes, to be driven by bad experiences with train travel and not to have a personal liking for trains and train travel.

Class 4: Transfer-averse train sceptics (12.6%)
The final class, class 4, definitely does not like to make a transfer. They are most likely to opt for a transferless alternative and are very sensitive to additional transfers. Class 4 is the least cost-sensitive class and is therefore willing to pay for conveniences like fewer transfers, but also to avoid bad service. When making a transfer is inevitable, this class prefers a high transfer time. People in class 4 are also somewhat likely to opt for other modes of transportation over train travel. This is reflected in the fact that a person who is driven by their bad experiences with train travel is likely to belong to this class.

6.2.2. Parameter estimates

In table 6.4, all parameter estimates and their z-value are shown. The model estimated a parameter for each attribute as well as for all the class intercepts and the covariates. All parameter estimates that are statistically significant are marked green and bold.

Table 6.4: Parameter estimates LCCM

		Class 1: Time-Valuing Eco-Advocates		*Class 2: Cost-Sensitive Train Travellers*		*Class 3: Train Dislikers*		*Class 4: Transfer-Averse Train Sceptics*	
Attributes		**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**
cost		**-3,21**	-9,76	**-8,58**	-13,04	**-3,48**	-4,74	**-2,99**	-3,62
transfertime		**7,00**	8,02	2,27	1,80	2,74	1,35	**5,01**	2,05
sq_transfertime		**-6,33**	-7,10	-2,01	-1,55	-3,69	-1,65	-3,58	-1,47
totaltraveltime		**-7,08**	-18,96	**-3,31**	-7,06	**-4,78**	-5,97	**-5,73**	-5,92
numberoftransfers		**-1,68**	-17,84	**-1,12**	-8,52	-0,35	-1,53	**-1,67**	-6,03
distribution	even	0,01	0,12	0,16	1,87	-0,05	-0,26	-0,26	-1,37
	unevenLS	0,08	1,27	-0,02	-0,27	-0,17	-1,00	0,02	0,11
	unevenSL	-0,08	-1,33	-0,13	-1,49	0,21	1,31	0,24	1,38
service	light	**-0,39**	-5,55	**-0,23**	-2,75	**-0,45**	-2,40	**-0,64**	-2,92
	standard	0,04	0,58	0,06	0,64	0,01	0,08	0,36	1,92
	premium	**0,35**	5,38	0,17	1,86	**0,43**	2,91	0,28	1,54
notransfer		**1,06**	3,74	0,27	0,65	1,21	1,42	**4,26**	4,66
nopick		**-12,77**	-24,21	**-14,35**	-16,16	**-4,67**	-4,88	**-9,64**	-8,24

	Class 1		*Class 2*		*Class 3*		*Class 4*	
Intercept	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**
	0,87	1,26	0,12	0,16	1,20	1,56	-2,19	-1,31

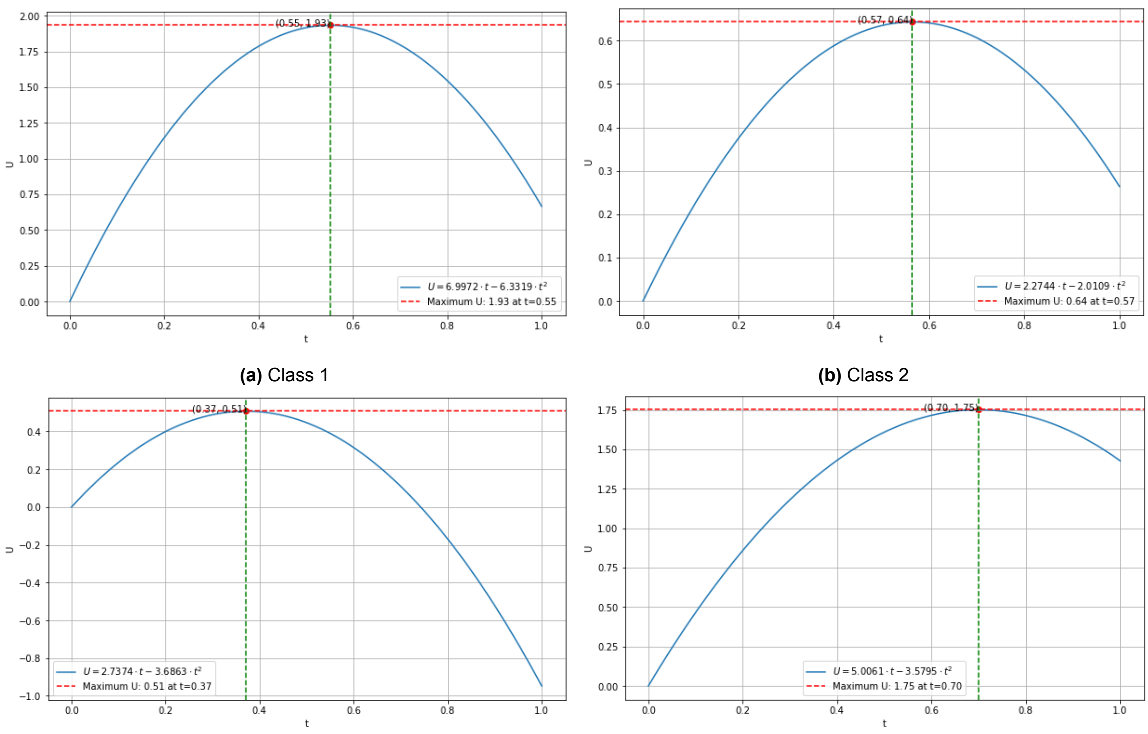
		Class 1		*Class 2*		*Class 3*		*Class 4*	
Covariates		**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**
ENVIRONMENT		**0,28**	2,19	0,26	1,72	**-0,46**	-3,10	-0,08	-0,46
EXPERIENCE		-0,19	-1,50	**-0,42**	-2,73	**0,28**	1,96	**0,34**	2,00
LIKING		0,06	0,43	0,04	0,27	**-0,35**	-2,27	0,25	1,32
PROVINCE	Other	-0,02	-0,25	0,15	1,22	0,06	0,53	-0,18	-1,32
	Randstad	0,02	0,25	-0,15	-1,22	-0,06	-0,53	0,18	1,32
INCOME	High	0,04	0,20	-0,38	-1,49	0,09	0,35	0,25	0,95
	Low	-0,32	-1,23	**0,52**	2,06	0,26	0,94	-0,45	-1,16
	Mid	0,15	0,97	-0,09	-0,49	0,02	0,11	-0,08	-0,37
	Unknown	0,13	0,76	-0,05	-0,23	-0,36	-1,63	0,28	1,15
CARS	No	0,01	0,12	0,12	1,00	-0,15	-1,21	0,02	0,14
	Yes	-0,01	-0,12	-0,12	-1,00	0,15	1,21	-0,02	-0,14
GENDER	Female	0,13	1,34	**-0,38**	-2,94	0,14	1,16	0,10	0,78
	Other	-0,13	-1,34	**0,38**	2,94	-0,14	-1,16	-0,10	-0,78
AGE		0,00	0,07	0,01	1,15	-0,02	-1,56	0,00	0,35
TRAINUSE	Often	0,01	0,13	-0,13	-1,10	-0,06	-0,46	0,18	1,28
	Seldom	-0,01	-0,13	0,13	1,10	0,06	0,46	-0,18	-1,28
WORKSTATUS	Other	-1,18	-1,84	-0,58	-0,93	0,09	0,15	1,67	1,04
	Retired	-0,33	-0,55	-0,72	-1,13	-0,78	-1,21	1,84	1,14
	Student	1,01	0,66	0,77	0,50	0,76	0,49	-2,54	-0,57
	Unknown	0,93	0,60	1,04	0,67	0,50	0,32	-2,47	-0,54
	Working	-0,43	-0,78	-0,51	-0,91	-0,57	-1,01	1,50	0,96
EDUCATION	High	0,22	1,81	-0,18	-1,34	-0,05	-0,40	0,02	0,10
	Low	-0,22	-1,81	0,18	1,34	0,05	0,40	-0,02	-0,10
LD_TRAVEL	Often	-0,21	-1,69	-0,04	-0,28	**0,38**	2,23	-0,13	-0,78
	Seldom	0,21	1,69	0,04	0,28	**-0,38**	-2,23	0,13	0,78
LD_TRAIN	Never	-0,05	-0,38	-0,22	-1,52	**0,50**	3,13	-0,23	-1,36
	Yes	0,05	0,38	0,22	1,52	**-0,50**	-3,13	0,23	1,36
MOTIVE	Business	-0,29	-1,52	-0,06	-0,29	0,37	1,66	-0,02	-0,06
	Leisure	0,29	1,52	0,06	0,29	-0,37	-1,66	0,02	0,06
COMPANY	Alone	0,11	0,58	0,08	0,34	-0,09	-0,33	-0,10	-0,39
	Other	0,02	0,09	-0,02	-0,09	-0,11	-0,51	0,12	0,54
	Partner	-0,13	-0,72	-0,06	-0,27	0,20	0,88	-0,01	-0,06

Again, note that a significance level is given for all the levels of the nominal attributes. This is because the used software (Latent GOLD) estimates the model multiple times, each time picking another level as the reference level.

Attributes

For each class, **cost** has a negative parameter estimate. All estimates are significant. This indicates that anyone dislikes extra costs, and this significantly contributes to an alternative's attractiveness. Class 2 is the most cost-sensitive, as this parameter estimate has the highest absolute value. An equal change in cost has a greater impact on utility for this class than for other classes. The other three classes are much less cost-sensitive (more than twice less), and class 4 is the least cost-sensitive.

When we further explore the **transfer time** attribute, we find that it is not statistically significant for class 2 and class 3. This means that within those classes, transfer time does not contribute to the utility of an alternative. For class 4, only the linear component is statistically significant. This implies that for this class, there is no statistical evidence for curvature and the relationship might be linear. Nevertheless, in this model, we are approaching it as quadratic, while keeping in mind this insignificance. Class 1 is the most sensitive to changes in transfer times. Furthermore, we can calculate the optimal transfer time for each class. The transfer time is plotted against the utility contribution in figure 6.3. It is found that the optimal transfer time for class 1 is 33 minutes, for class 2 it is 34,2 minutes, for class 3 it is only 22,2 minutes, and for class 4 it has a relatively high value of 42 minutes. This indicates that members of class 2 prefer shorter transfer times, although it does not weigh in on their travel decisions. Class 4 prefers higher transfer times.



(a) Class 1 **(b)** Class 2

(c) Class 3 **(d)** Class 4

Figure 6.3: Utility contribution of transfer time plotted for each class

The parameter estimates of **travel time** are significant and negative for all four classes. This implies all classes dislike higher travel times and they factor travel time into their travel choices. Class 1 is the most sensitive to these attributes, and class 2 is the least sensitive, more than twice less sensitive than class 1.

When looking at the estimates of the **number of transfers** attribute, we find that the parameter estimate for class 3 is not statistically significant. This implies that members of class 3 are indifferent to the number of transfers and do not care whether they have to transfer 1 or 2 times. The other estimates are all significant and negative, indicating that more transfers have a negative impact on the attractiveness of an alternative. Class 1 and class 4 are the most sensitive to this attribute.

All levels of the **time distribution** are insignificant for all classes. This means that time distribution has no impact on choice behaviour in this population sample.

The estimates of the **service** attribute vary per class. For class 1 and class 3, the parameters are statistically significant for the 'light' and the 'premium' levels, implying only these contribute negatively or positively to the utility of alternatives. For class 2 and class 4, only the 'light' level is statistically significant. Class 4 has the largest dislike for the 'light' level, and class 3 has the largest preference for 'premium'. Class 3 is overall the most sensitive to this attribute.

The alternative specific constant for the transferless option, **'notransfer'**, is only significant in class 1 and class 4. This means that for the other classes, there is not enough evidence that this constant is different from 0. It is noteworthy that the ASC in class 4 is more than four times larger than in class 1. This indicates that people in class 4 have a stronger intrinsic preference that is not described by the attributes for a transferless journey than people from class 1. The constant ensures that the alternative inherently has a higher utility. In class 4, this effect is much stronger than in class 1. In the other classes, it has no significant impact at all.

The ASC for the opt-out alternative, **'nopick'**, is significant for all classes. It is interesting to compare the constant estimates of the different classes. The utility of the opt-out consists only of this constant. This means that when this constant is low, people in the class are less likely to pick the opt-out alternative. When it is higher, they are more likely. We see that the lowest constant estimate belongs to class 2, indicating that in this class people are most prone to choose train options. The highest estimate belongs to class 3, indicating that in this class people are the most prone to opt out and thus choose for another means of transportation. Classes 1 and 4 score in between, but people from class 1 are more likely to choose the train than people in class 4.

Covariates

Finally, we look at the parameter estimates of the covariates. From the model, it becomes clear that only some of the covariates relate to the latent class variable in this population.

For class 1, the covariate **'ENVIRONMENT'**, which indicates a person's intention to use environmentally friendly modes, has a significant positive estimate. This means that someone with a higher intention to use environmentally friendly modes is more likely to belong to this class (or someone with a lower intention is less likely).

For class 2, the covariate **'EXPERIENCE'**, representing the extent to which a person is driven by their bad experience with train travel, has a significant and negative estimate. This indicates that someone who is less driven by their bad train travel experience is more likely to belong to this class. Additionally, the **'INCOME'** level 'Low' has a significant positive estimate, suggesting that someone with a low income is more likely to belong to this class. The **'GENDER'** indicator shows significant parameter estimates, with a negative estimate for 'female' and a positive estimate for 'other', indicating that someone who is not female (thus male or another gender) is more likely to belong to this class.

For class 3, the covariate **'ENVIRONMENT'** has a significant negative estimate, meaning that someone with a lower intention to use environmentally friendly modes is more likely to belong to this class (or someone with a higher intention is less likely). The **'EXPERIENCE'** covariate has a significant positive estimate, indicating that people who are more driven by their bad train travel experience are more likely to belong to this class. The covariate **'LIKING'**, which represents a person's personal liking for trains and train travel, has a significant negative score. This suggests that someone who does not like trains and train travel is more likely to belong to this class, aligning with the positive score on 'EXPERIENCE', as people driven by bad experiences with train travel are logically not fond of trains. Class 3 also has significant indicators for both levels of **'LD_TRAVEL'** and **'LD_TRAIN'**. The positive indicator for 'often' in 'LD_TRAVEL' suggests that people who have travelled often in the past year are more likely to belong to class 3, while the positive indicator for 'never' in 'LD_TRAIN' indicates that people who have not made any of their trips by train are also more likely to belong to this class.

Finally, for class 4, the covariate **'EXPERIENCE'** also has a significant positive estimate, indicating that people who are more driven by their bad train travel experience are more likely to belong to this class. This class has no other significant covariate estimates.

Overall, it is interesting to see that not many of the covariates pose a significant impact on the class probabilities. The estimated factors give the most significant estimates, but there are barely any socio-demographics with a likely relationship with the latent class variable. Class 1 and class 4 only have one significant covariate estimate, which is very little to draw interesting conclusions from.

6.2.3. Importance of attributes

To compare differences in choice behaviour between classes, we also look at the importance and relative importance of the six attributes. Just like in the MNL model, this is done with the maximum utility difference. The maximum utility difference is calculated with the absolute difference between the minimum and maximum utility contribution based on the levels included in this experiment. Table 6.5 shows per class what the maximum utility difference and relative importance of each attribute is. The relative importance is also graphically shown in figure 6.4. It is important to note that this relative importance is not absolute but also relative to the selected attribute level variance in this experiment. A smaller variance in attribute levels would automatically lead to a smaller utility difference, and a lesser importance. Yet, these values are presented since the level variance in the experiment is based on real-life examples. Still, it is important to keep this in mind.

Table 6.5: Maximum utility difference and relative importance per attribute per class

	Class 1: Time-Valuing Eco-Advocates		*Class 2: Cost-Sensitive Train Travellers*		*Class 3: Train Dislikers*		*Class 4: Transfer-Averse Train Sceptics*	
Attribute	**Max. utility difference**	**Relative importance**	**Max. utility difference**	**Relative importance**	**Max. utility difference**	**Relative importance**	**Max. utility difference**	**Relative importance**
Travel cost	1,93	22%	5,15	59%	2,09	33%	1,79	21%
Transfer time	1,39	16%	0,47	5%	0,78	12%	1,31	15%
Travel time	2,83	32%	1,32	15%	1,91	30%	2,29	27%
Number of transfers	1,68	19%	1,12	13%	0,35	6%	1,67	20%
Time distribution	0,16	2%	0,29	3%	0,38	6%	0,50	6%
Service	0,74	9%	0,40	5%	0,88	14%	1,00	12%
Total	*8,73*	*100%*	*8,76*	*100%*	*6,39*	*100%*	*8,56*	*100%*

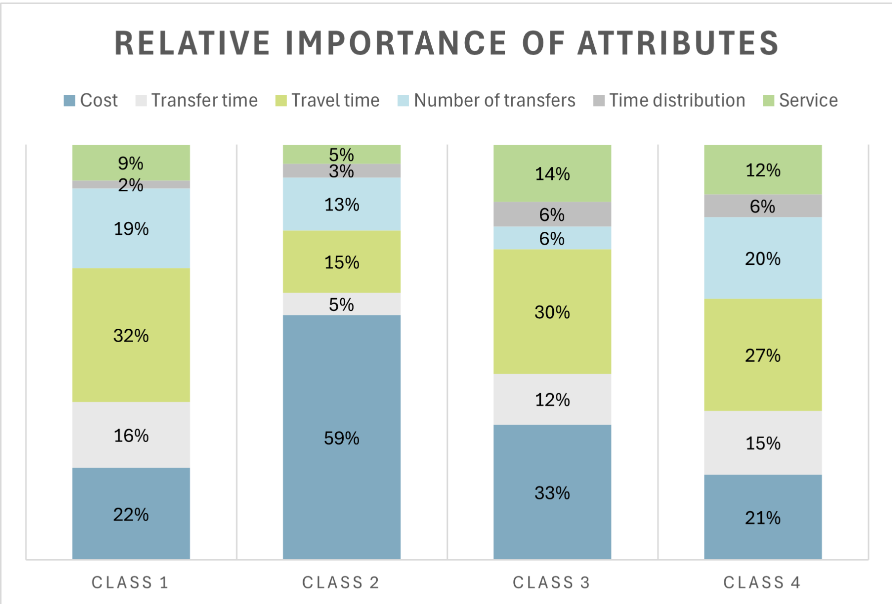


Figure 6.4: Relative importance of attributes per class

From these results, it becomes clear that overall, class 3 is the least sensitive as the maximum utility differences of these attributes sum up to a lower number than the other classes which have equal totals.

This is not surprising since this is the class that dislikes trains, so they naturally care less about train attributes. Furthermore, it becomes obvious that class 2 is the most cost-sensitive and cares way less about all other attributes. They are willing to make a longer journey if this saves them costs. Class 1 is the most sensitive to the transfer time. Class 3 relatively cares very little about additional transfers and is the most service-prone, while class 4 has a higher maximum utility difference for service but they also find other attributes important. For example, class 4 and class 1 have the strongest dislike for additional transfers.

6.2.4. Willingness to pay

To express the estimates in monetary values, a willingness to pay (WTP) for each attribute level increase is calculated. Table 6.6 shows these results. In the cost attribute row, for each class, the willingness to pay for an increase of one 'util' is noted which is calculated with the utility difference from an increase in the cost attribute. Note that under travel time, the WTP for one hour is also calculated, denoting the value of time (VoT) of that class.

Table 6.6: WTP for attribute level increases per class

		Class 1: Time-Valuing Eco-Advocates		*Class 2: Cost-Sensitive Train Travellers*		*Class 3: Train Dislikers*		*Class 4: Transfer-Averse Train Sceptics*	
Attribute	**Level increase**	**Utility diff.**	**WTP**	**Utility diff.**	**WTP**	**Utility diff.**	**WTP**	**Utility diff.**	**WTP**
Travel cost	-	1	€31,15	1	€11,65	1	€28,77	1	€33,48
Transfer time	5 - 20 min	1,09	€33,94	0,36	€4,18	0,30	€8,64	0,88	€29,42
	20 - 35 min	0,23	€7,14	0,11	€1,26	-0,16	€-4,61	0,43	€14,44
	35 - 50 min	-0,49	€-15,36	-0,14	€-1,67	-0,62	€-17,87	-0,02	€-0,54
Travel time	+ 2 hours	-1,42	€-44,07	-0,66	€-7,71	-0,96	€-27,49	-1,15	€-38,37
	+1 hour (VoT)	-0,71	€-22,04	-0,33	€-3,85	-0,48	€-13,75	-0,57	€-19,19
Number of transfers	1 - 2	-1,68	€-52,37	-1,12	€-13,08	-0,35	€-10,18	-1,67	€-55,91
Time distribution	unevenLS - even	-0,07	€-2,16	0,18	€2,10	0,12	€3,53	-0,28	€-9,37
	even - unevenSL	-0,09	€-2,87	-0,29	€-3,41	0,26	€7,48	0,50	€16,74
Service	light - standard	0,43	€13,34	0,29	€3,41	0,46	€13,25	1,00	€33,33
	standard - premium	0,32	€9,84	0,11	€1,29	0,42	€12,04	-0,07	€-2,40

The information in this table complements the findings in the previous two subsections and provides some valuable insights.

Class 1 has the highest VoT, which is not surprising considering they are the most time-sensitive. Their VoT is €22,04 per hour. Also unsurprisingly, the lowest VoT is found for class 2, since they are very cost-sensitive and not so much time-sensitive. Their VoT is only €3,85 per hour. The VoT of class 3 is closer to the average found in the previous section and is estimated to be €13,75 per hour. Finally, the VoT of class 4 is quite high, €19,19 per hour.

Another huge difference between the classes is that classes 1 and 4 have a much higher WTP for making one transfer instead of two (€52,37 and €55,91 respectively) than classes 2 and 3 (€13,08 and €10,18 respectively). This difference is in line with the fact that class 3 is very indifferent to transferring and class 2 is very cost-oriented. We also learned that class 4 is particularly transfer-averse. However, the difference is still very big. But when considering the VoT of each class, the additional transfers resemble an additional travel time of approximately 2 hours and 20 minutes for class 1, 2 hours and 55 minutes for class 2, 3 hours and 25 minutes for class 3, and only 45 minutes for class 4. So class 1 and 4 both have large monetary and temporal transfer 'penalties', class 2 has a small monetary transfer penalty but a high temporal transfer penalty, and class 3 has a low transfer penalty in both terms, mainly due to the fact that they are very indifferent overall. To add to this, it is also found that people from classes 1 and 4 are willing to pay more for better transfer times.

When zooming in on the WTP for service level, it can be seen that people from class 4 are willing to pay a lot (€33,33) for an upgrade from the 'light' service level to the 'standard' service level. Considering their VoT, this corresponds to 1:45h of additional travel time. However, they do not have much to show for an additional upgrade to 'premium' service (only €2,40, or 8 minutes of additional travel time). Furthermore, classes 1 and 3 are both willing to pay a little more for better service.

7
Application

In this chapter, the changes in market share of long-distance train travel including and excluding transfers are explored by applying the results of the MNL and the LCCM. This is done by calculating the choice probabilities of choosing an alternative for each class, and on average.

As discussed in chapter 1.1, transfers are becoming crucial elements of an efficient, good-performing railway network. Consequently, in the design of the European railway network, some design problems might arise. This chapter discusses multiple scenarios in these dilemmas and calculates class-dependent market shares for each scenario. Note that these market shares are hypothetical, as they are based only on the context of this study.

First, the different scenarios are described. Next, for each scenario, the demand response will be calculated for three types of long-distance travel: Long-distance train travel including transfer(s), long-distance direct train travel, and long-distance travel with other modes (for example car or plane). The latter two are static in these scenarios and equal to how they were included in the survey. It is important to note that the direct train travel option is fixed ad very bad conditions, and the substitution calculated in this chapter is between transfer alternatives and a bad direct option. Also, the other modes do not have anything specified, like costs or time. Therefore, the market share of the transfer options is relatively high.

7.1. Scenario descriptions

Six different scenarios are distinguished, one is a base scenario, the next four focus on optimizing a specific aspect of the journey, and the last scenario is a purely hypothetical best-case scenario that leads to the highest average market share of train journeys with transfer. Optimizing a specific aspect of the journey also means that sacrifices in other areas must be made. Table 7.1 gives an overview of the attributes of the train with transfer alternative per scenario. Since time distribution was found to be insignificant for all classes, it was not included in these scenarios. The transferless option has a travel cost of €110, a travel time of 12 hours, and a light service level. This alternative is also influenced by its ASC. The opt-out alternative is only influenced by its ASC.

Table 7.1: Attributes train transfer alternative per scenario

Attribute	Base	Fast	Cheap	High service	Good transfer	Best
Travel cost	€ 90	€ 90	€ 50	€ 110	€ 70	€ 50
Transfer time	50 min	5 min	50 min	35 min	35 min	35 min
Travel time	8 hours	8 hours	12 hours	10 hours	8 hours	8 hours
Number of transfers	1	2	2	1	2	1
Service	Light	Standard	Light	Premium	Standard	Premium

Base scenario

The base scenario is built upon what trips are currently on the market within the context of this study, therefore, a trip from Amsterdam to Basel was looked at, booking two months ahead of the travel date. A conscious effort was made to find a reasonably inexpensive option. The found option costs 85 euros, which is rounded up to the nearest cost level of 90 euros. It is important to note that this price ranges widely over different seasons and leaving times. The journey includes one transfer in Cologne of 42 minutes, which is rounded to the nearest level of 50 minutes. The in-vehicle travel time of this trip is about 8 hours, and no services are provided with this booking. This scenario is used as a reference to the other scenarios.

Fast scenario
The next scenario is the fast scenario. The goal of this trip will be to get from A to B in as little time as possible. This means a low travel time, but also a low transfer time. Additionally, to establish a fast connection, two transfers will have to be made. The price of the trip will also be on the higher side, but it will cover a standard service level.

Cheap scenario
In this low-cost scenario, all choices are made in such a way that the booking price can be as cheap as possible. This means a high travel time and transfer time. It will also include 2 transfers and have no additional services. It is expected that this scenario will be especially popular among class 2, since that is the most cost-oriented class.

High service level scenario
This scenario aims for a high level of customer service. It is meant for travellers who value service over other aspects. However, in reality, this high service comes with additional costs. In this scenario, the length of the trip will be average, but the transfer time is near optimal. It includes only one transfer to keep customers as happy as possible.

Good transfer scenario
This scenario revolves around incorporating more transfers in the railway network and optimizing its characteristics. Therefore, the number of transfers in this scenario is 2, and the transfer time is 35 minutes, which was found to be the most optimal transfer time level in general. When transfers are well integrated, the travel time is also expected to become lower. The high number of transfers leads to a cheaper option, while still honouring a full refund policy.

Best-case scenario (hypothetical)
As a reference to all other scenarios, the final scenario is designed in such a way that the utility of the train with transfer alternative is as high as possible. This can be used as a future goal, which aims for a cheap, fast option with minimal transfers, a good transfer time, and a high level of service.

7.2. Choice probabilities

For each scenario, the probability of choosing an alternative was calculated by dividing the exponent of the utility over the sum of exponents of the utilities of all alternatives (see equation 2.3. The results of these calculations can be found in table 7.2. The percentages indicate that a member of a certain class has a certain probability of choosing a certain alternative. Not that the 'average' column is the population estimation over this population sample.

In table 7.2, the differences between the latent classes become extra clear. For example, class 3 are real train dislikes and the majority will always choose another mode, regardless of the scenario. Even in the hypothetical best-case scenario, there is still a chance of over 60 % that a member of class 3 will not choose to travel by train. This confirms that class 3 had an intrinsic dispreference for travelling by train. Class 4 disfavors making a transfer, which is clearly visible in the choice probabilities of the direct train alternative. The choice probability of someone in class 4 choosing the direct train is in every scenario a lot higher than for any other class. Class 2 is very cost-oriented, leading to a very high probability of choosing the train + transfer alternative in the cheap scenario.

Comparing the different scenarios, you can see that the base scenario already performs pretty well. On average, the probability of choosing the train + transfer alternative in the context of this study is above 50%, while this is much lower for the fast, cheap, and high-service scenario. However, in the good transfer scenario, the probability of choosing this alternative is on average a little higher. This indicates that when the entire railway network is very well integrated, additional transfers do not necessarily lead to a lower market potential. Nonetheless, it is important to note that this scenario is not very feasible with the current state of the European railway network. It requires more development and policy implications. However, it is also shown that the difference between choosing the transfer alternative between the base scenario and the good transfer scenario is not positive for every class. The average increase is 6,9%, but for class 1 there is a decrease of 1,8%, for class 2 there is an increase of 9,2%, for class 3 there is an increase of 10,8%, and for class 4 there is a decrease of 39,3%. This result indicates that the areas of interest lie with classes 2 and 3, so cost-sensitive train travellers and train dislikers. Within these groups, the most gains can be achieved with this good transfer design.

Table 7.2: Choice probabilities per scenario per class

		Train + transfer	Direct train	Other mode
Base	*Average*	*52,3%*	*22,6%*	*25,1%*
	Class 1	87,5%	10,1%	2,4%
	Class 2	82,0%	12,1%	6,0%
	Class 3	6,1%	0,4%	93,5%
	Class 4	74,9%	24,1%	1,1%
Fast	*Average*	*22,7%*	*36,6%*	*40,7%*
	Class 1	44,0%	45,0%	10,9%
	Class 2	65,1%	23,3%	11,6%
	Class 3	9,2%	0,4%	90,4%
	Class 4	2,4%	93,4%	4,2%
Cheap	*Average*	*22,4%*	*36,8%*	*40,9%*
	Class 1	21,7%	63,0%	15,3%
	Class 2	92,4%	5,1%	2,5%
	Class 3	3,7%	0,5%	95,8%
	Class 4	15,8%	80,6%	3,6%
High service	*Average*	*34,1%*	*31,2%*	*34,7%*
	Class 1	75,5%	19,7%	4,8%
	Class 2	34,7%	43,6%	21,6%
	Class 3	2,9%	0,5%	96,6%
	Class 4	22,0%	74,6%	3,4%
Good transfer	*Average*	*59,2%*	*19,3%*	*21,5%*
	Class 1	85,7%	11,5%	2,8%
	Class 2	91,2%	5,9%	2,9%
	Class 3	16,9%	0,4%	82,7%
	Class 4	35,6%	61,6%	2,8%
Best	*Average*	*91,8%*	*3,9%*	*4,3%*
	Class 1	98,9%	0,9%	0,2%
	Class 2	99,4%	0,4%	0,2%
	Class 3	38,6%	0,3%	61,1%
	Class 4	84,2%	15,1%	0,7%

Class 1: Time-Valuing Eco-Advocates
Class 2: Cost-Sensitive Train Travellers
Class 3: Train Dislikers
Class 4: Transfer-Averse Train Sceptics

7.3. Real-life example: Amsterdam-Basel

Since all the formulated scenarios are hypothetical and within the context of this study, it is also interesting to see how the implementation of a transfer connection rather than a direct one would look in a real-life scenario. Therefore, the case of Amsterdam-Basel is considered. Up until the summer of 2024, there was a direct train connection between The Netherlands and Switzerland. However, this connection will be discontinued due to long-term rail construction work in Germany (Treinreiziger.nl, 2024). This is a practical example of a situation where the implementation of transfers is inevitable.

A new connection between Amsterdam and Basel (including one transfer) was used as the foundation of the base scenario in the previous sections. This scenario will now be compared to the previous situation, as well as another possible configuration with two transfers. This second configuration has an in-vehicle time of 7 hours and 30 minutes and includes two transfers in Düsseldorf and Mainz. Both transfers are about 60 minutes. The cost of a second class ticket for this journey booked 2 months in advance is 60 euros.

The direct (day) train between Amsterdam and Basel (ICE105) uses the High-Speed Rail (HSR) network has a short duration of 6 hours and 39 minutes. It passes through Utrecht, Arnhem, Duisburg, Düsseldorf, Cologne, Frankfurt, and some other intermediate stations. The costs of such a trip are a little higher than the conventional train and for this experiment fixed at €95.

Since the three trips do not have different service policies these are all fixed at the light level. Table 7.3 gives an overview of the three trips. Note that in this implementation the attribute level boundaries of the studies are not maintained, and an attribute can take any value.

Table 7.3: Real-life examples Amsterdam-Basel

Attribute	**Direct train (old)**	**One transfer (new)**	**Two transfers (new)**
Travel cost	€95	€85	€60
Transfer time	-	42 min	60 min
Travel time	6,5 hours	8 hours	7,5 hours
Number of transfers	0	1	2
Service	Light	Light	Light

With these values, the choice probabilities of choosing one of these options versus choosing another mode are calculated per class for the old and new situations. The results of these calculations are shown in table 7.4.

Table 7.4: Choice probabilities real-life examples

		Train		Other mode
Old (direct)	*Average*	*94,3%*		*5,7%*
	Class 1	99,7%		0,3%
	Class 2	97,8%		2,2%
	Class 3	10,1%		89,9%
	Class 4	99,9%		0,1%
		1 transfer	2 transfers	Other mode
New (transfer)	*Average*	*58,2%*	*24,6%*	*17,2%*
	Class 1	82,8%	15,8%	1,4%
	Class 2	23,1%	75,8%	1,1%
	Class 3	5,9%	17,9%	76,2%
	Class 4	29,4%	69,9%	0,7%

First of all, it is important to note that the interpretation of the 'other mode' option is not specified in this experiment, which can be one of the reasons why the choice probability is very low. It is also important to keep in mind that the respondents are all NS panel members, who apparently either strongly prefer or strongly avoid train journeys.

From the calculations, it is shown that the old configuration with the direct train makes for a more popular connection than the new configuration with the transfer options, which is not surprising as the old configuration was also very fast and not super expensive. In the old configuration, the average probability of not opting out (and thus choosing the train option) is 94,3%, while in the new configuration, this is 82,8%. However, when looking at the classes individually, the choice probability of the train alternative(s) of classes 2 and 3 actually increases for the new situation. This can be explained by these classes' sensitivity to the costs, or in the case of class 3 the insensitivity to all other attributes. For class 1, the chance of choosing another mode becomes more than 4 times higher in the new configuration, and for class 4 this chance becomes 7 times higher. The results also show that the variety in travel options when offering transfer alternatives is of great importance. Class 1 has a substantially bigger preference for the 1-transfer option, while the other classes prefer the 2-transfer option.

What we can learn from this real-life example is that transfer trips will very easily be considered less attractive than direct trips. However, by offering a variety of possibilities within transfer options, the potential of long-distance train travel can be increased. We also learn that for a large part of the population, people's behaviour is greatly influenced by costs. So if we want to design a railway network with a large market potential, we should prioritize finding a way to reduce ticket prices. The attractiveness of train travel might also be increased by increasing the level of service offered, however, this will have a less substantial impact.

8
Conclusion and discussion

In this chapter, conclusions will be drawn from the findings of the study. These conclusions will answer the research questions that were formulated in chapter 1.4. Additionally, possibilities for policy implications will be discussed. This chapter will also elaborate on the limitations of this study and make recommendations for future research in the field.

8.1. Key findings

This research aimed to answer the following main research question:

What is the effect of transfer attributes on itinerary choice behaviour in long-distance train journeys?

To answer this question thoroughly and comprehensively, each formulated sub-question will be answered individually.

1. What transfer attributes can influence a traveller's decision-making process when choosing a long-distance train journey through Europe?

This question was answered with literature and focus group research. In the literature, it was found that there are mainly three types of transfer attributes that influence a travel choice. First, there are physical transfer attributes, which include physical characteristics of the transfer station, like for example the presence of facilities, elevators, shelter or real-time information. Secondly, there are operational attributes which define the itinerary of a trip, like for example travel time, transfer time, number of transfers, and travel costs. Finally, there are service attributes, which can enhance the quality of the travel experience. These include for example security, safety, comfort and insurance.

Due to a lack of available research in long-distance train context, the literature research reviewed studies in urban transit context and long-distance air travel context. It was found that in urban context, choices were mostly driven by operational factors like time and cost, while in long-distance air travel context, service factors also play a big role. Therefore, a service attribute was included in the study along with operational factors.

The results from the focus group supported the findings of the literature research, and defined the specific attributes to include. Some obvious attributes that came forth were costs, transfer time, travel time, and the number of transfers. Based on the focus groups it was also decided to include the time distribution of the trip, indicating how long a passenger would be in each separate train and if the transfer(s) occurred in the beginning. middle, or end of the journey. The service attribute also came back during the focus group and was included in the study.

Based on the results of the literature and focus group research, we conclude that mainly operational and service transfer attributes are of influence in a traveller’s decision-making process when choosing a long-distance train journey through Europe. It is suspected that improvements in these areas will have the highest impact on travellers’ choice behaviour.

2. How are the different attributes of a transfer in a long-distance train journey valued on average by potential users?
On average, it was found that the transfer attributes are subordinate to general operational travel attributes like travel cost and travel time. It was found that in the decision-making process, travel cost has a relative importance of 35% and travel time has a relative importance of 27%. Both were estimated to have a linear relationship to the utility of an alternative with a negative direction, indicating that additional travel costs and travel time result in a less attractive alternative. Based on the data from the population sample, people are on average willing to pay €11,95 for an hour less travel time. This means that improving the transfer itself will not have a very large impact on the choice behaviour, as people will always look at cost and time first, and value this more than the design of the transfer.

The next most important attribute is found to be the number of transfers, which has a relative importance of 17%. The number of transfers showed a negative effect on the attractiveness of an alternative, indicating that people prefer as few transfers as possible. On average, people from the sample are willing to pay about €30 euros to make one less transfer. This WTP is interesting to incorporate in the pricing strategies of train journeys. 30 euros is a hefty share of the discussed price range. Adding a transfer will thus always be very unfavourable and should be heavily compensated.

The transfer time is found to have a quadratic relation to the attractiveness of an alternative. This means that the transfer time should not be too short, nor should it be too long, The average optimal transfer time is found to be roughly 31 minutes. This means that people in the population sample generally have a preference for an alternative with a transfer time close to 31 minutes. Looking at the bigger picture, this result implies it would increase the potential of international train travel if timetable makers would take a transfer time of a little over 30 minutes into account. However, transfers overall have a less significant impact on choice behaviour than travel time and travel cost.

The level of service is found to have a significant yet small effect on the attractiveness of an alternative. With relative importance of only 7%, the service level is estimated to be less important than initially anticipated based on the literature review. On average, people from the population sample are willing to pay only €11,43 to travel with flexible travel times, receive a refund for the full journey and get assigned a seat on an alternative train in case of disturbances (upgrade from light to premium service level). This result is in contrast with what was expected based on the literature and focus group outcomes. This could be because people really care less about service than they say, but service was also very simplified in this experiment. It might have been hard for the respondents to distinguish the different levels correctly. Service covers a variety of aspects that are hard to quantify. Further research would be necessary to see if a better quantification leads to different results.

The time distribution, i.e. when in the journey the transfer appears, was found to have no significant effect on the choice behaviour of the respondents. This indicates that timetable makers do not need to consider the time distribution and at what moments transfers occur.

3. What different segments can be identified in the population, and what characteristics do they exhibit in their decision-making behaviour?
Four segments of people with similar choice behaviour were identified in the population sample. The largest segment (44,4% of the population sample) mainly values time and is willing to pay to get to their destination as fast as possible. People with a high intention to use environmentally friendly modes of transportation are more likely to belong to this class. The second-biggest segment (25,0%) bases their travel choice almost solely on costs. Consequently, people with low incomes are more likely to belong to this class. However, they prefer to travel by train and are not easily influenced by bad experiences with train travel. The third segment (18,1%) is not a fan of train travel and prefers other means of transportation. They value better service and are likely to be influenced by bad experiences. People with a lower intention to use environmentally friendly modes are more likely to belong to this class. Finally, the fourth segment (12,6%) particularly does not like to make a transfer. They are willing to pay more than other segments for a transferless trip and are wary of choosing short transfer times. They are sceptic about trains as they are also likely to be driven by bad experiences with train travel.

The socio-demographics that were included in the study had for the most part no significant relationship to the latent class variables. Long-distance travel behaviour in the past year had a relationship to one of the four classes. All classes had a relationship to one or more of the measured factors. These turned out to be most decisive for the choice behaviour of the classes.

These classes are derived from an NS panel sample and do not necessarily represent the population. Nonetheless, we see that within this sample, there is a group of people that is very unwilling to use the train and very hard to persuade. So the differences have to be made in the other part of the population. There are a lot of people who are open to the idea of train travel, but encounter obstacles to make them choose otherwise. By targeting this group with marketing and minimising these obstacles, the market share of long-distance train travel can be maximised.

4. What does a 'good' transfer in long-distance train journeys look like?
In this research, it is found that a good transfer in a long-distance train journey allows for a quick connection between the origin and the destination of the travellers. Travel time is one of the heaviest weighing factors in travel choices. A transfer can therefore surpass a direct connection by significantly reducing the total travel time. Additionally, the ideal transfer time in a long-distance train journey is found to be somewhere between 22 and 42 minutes. This gives the traveller enough confidence that they will make the transfer, without having to endure endless waiting times at intermediate stations. It is also important to keep the number of transfers limited. If the transfer is early, in the middle, or late in the journey does not improve the quality of the transfers. A better service system might enhance a transfer, by for example offering a transfer guarantee or better refund schemes, so that people have to rely less on their self-sufficiency when there is a disruption.

Looking back at the starting point of this research, transfers are important and necessary components of an efficient, integrated railway network. In chapter 7, it was found that by designing a transfer as well as possible, there is a profit to be gained relative to the current situation. However, this design requires much improvement in the collaboration within the network on operational, tactical, and above all strategic levels. Thus, there is definitely potential; now, the focus must be on the execution.

Main research question: What is the effect of transfer attributes on itinerary choice behaviour in long-distance train journeys?
To conclude the key findings, a brief review of the main research question will be made. The effect of transfer attributes on itinerary choice behaviour in long-distance train journeys is definitely substantial, however, the effect of travel cost and travel time is bigger. The fact that travellers generally find transferring unpleasant is logical and once again confirmed by this research. Yet, the reasons why a transfer is found unpleasant, which aspects of a transfer are of greater influence, and to what extent this affects their travel behaviour is very different for each traveller. This heterogeneity is captured in a latent class choice model that defines different segments among the population that exhibit similar choice behaviour. Each segment has different needs that should be accounted for. This research shows how this can be done. Implementing the results of this research contributes to the transfer towards European train travel.

8.2. Policy implications

With the findings of this research, some recommendations for policy implications are made.

First of all, it is important to maintain diversity in travel choice options, as this study highlighted the heterogeneity in passenger preference. To provide suitable options to as many travellers as possible, it is important to offer different options. Since this study found that a large part of the population sample values travel time, which is also on average the second highest valued attribute (after travel cost), it would be wise to set up a transfer in such a way that travel time is minimised. However, it is also important to offer some cheap options, as well as options with shorter or longer transfer times and improved service. In this way, as many travellers as possible are served in their needs.

However, it is important to prioritise which aspects to improve, as some were found to be way more important than others. To maximise the market potential of train travel on long distances, the first priority should be the reduction of ticket prices, as these seem to form the biggest obstacle. The next priority should be reducing travel times, by for example increasing the frequencies and speeds of the trains, as well as integrating the European network as a whole. When these two aspects are below a certain threshold, the train becomes a fair competitor to other modes. Then, improvements in transfers can really start to make a difference.

It is also recommended to use the outcomes of this study to improve demand forecasting models. This study has shown valuable insights for predicting choice probabilities based on people's experiences, attitudes, and socio-demographic characteristics. Using these predictions can improve the accuracy of forecasting models, which can be used in train scheduling algorithms. Relevant stakeholders such as national rail operators, transport ministries, and urban planning agencies should collaborate to integrate these insights into their existing models. By doing so, they can enhance the efficiency and reliability of long-distance train services in Europe.

The application of the results in chapter 7 shows that the improvements will have the greatest effect on a well-integrated, efficient European Railway network. Therefore, it is important to start taking steps in this matter. A first step could be improving the collaboration between the national railway operators, and maybe even creating alliances. Improving collaboration between different European rail operators can improve the potential of long-distance train travel, as travelling by train will become more seamless. These resemble alliances in air travel, like for example SkyTeam of which the Dutch airline KLM is a part. This will increase the ease of travelling by train, for example by improving booking convenience, offering more convenient itineraries, improving the overall collaboration between operators, and offering a better level of service to the passengers. In terms of transfers, alliances can ensure that international transfers are more compatible, and transfer setups can more easily be optimized. It might also be interesting to look at the feasibility of transfer guarantees. This means that a train will always wait for delayed preceding trains, or offer an alternative when this delay is too big to make up for it. With a transfer guarantee, people no longer rely on their self-reliance and the 'risk' that comes with a transfer (and makes a transfer unattractive) can be eliminated. However, this improvement is expected to have a lesser impact than the improvement in travel time and travel costs. Creating alliances can however be complicated in the context of train travel and the concept cannot simply be copied from air travel. In train travel, there are for example stronger national concerns as it relies on national subsidies, limited infrastructure, and concessions (and therefore a different form of competition). So in order to achieve this, clear agreements must be made between transit authorities of different countries, or even the option of a unified European transit government should be explored.

Furthermore, since European authorities are advocating for higher usage of international train travel, the results of this study can be used to conduct campaigns that are better targeted. Knowing which type of traveller is more susceptible to the idea of long-distance train travel and which are less, efforts can be made in places where campaigns are expected to have the greatest impact. Based on the outcomes of this study, it is advisable to start with a campaign to target people who are not intrinsically opposed to train travel (like class 3) but have other reasons why they would choose other modes, like cost-sensitivity (class 2) or transfer-aversion (class 4). A campaign about the better integration of the European train network with better transfer options as a result could be targeted at transfer-averse travellers (class 4). When targeting a cost-sensitive audience (class 2), the campaign can for example involve special offers and discounts. It could also be an awareness campaign to increase awareness of positive aspects of train travel, like environmental impact. Class 1 is already pretty train oriented, but could also benefit from any of the proposed campaigns. Targeting specific travellers is easier since more is known about the different choice behaviours than before this research started.

8.3. Limitations

When drawing conclusions from the results, it is important to keep the limitations of this study in mind. As this research is a master's graduation project, it had to deal with a limited time frame. Therefore, some assumptions and simplifications had to be made. This section discusses important limitations.

Focus groups

As mentioned, two focus groups were conducted. However, according to Krueger and Casey (2014), a focus group research works best with three or four groups. Only two were conducted due to limited time and means to recruit participants. This has limited the results of the focus group and made the identification of response biases hard. Conducting more focus groups would lead to better-substantiated results and a wider range of insights.

Travel time attribute

While constructing the survey, it was chosen to incorporate the attribute travel time as in-vehicle travel time and not as total travel time. The difference is that the total travel time includes the transfer time as well. However, to keep travel time separate from transfer time and limit the amount of attribute levels, it was chosen to use in-vehicle time. During the survey pilot, one major point of feedback was that people had to add up all the in-vehicle and transfer times because they wanted to make their decision based on the total travel time. Therefore, the total travel time was added to the survey visualisation. However, it was not modelled as such. Doing so would make the results a little more neat.

Survey dropouts

From the survey programmer at MWM2, we received updates on how many people filled out our survey. This amount was lower than they had expected based on previous surveys. A lot of people who started the survey did not finish it. MWM2 could tell that most survey dropouts occurred in the explanation section. This was apparently too extensive and made people quit the survey. In the future, we would advise leaving out most of the explanations and only include what is strictly necessary (in this case only the service attribute). The visualisations were designed to be intuitive and should not require further explanation.

Data filtering

Since a survey is human-based research, there is always a possibility of encountering human errors. For example, a person could fill out the survey randomly and submit it, without actually having read the questions or considered the answers. Some response patterns in the data of this research give the presumption that something like this might have occurred. However, there was no actual evidence to supportably exclude such responses. Incorporating a question in the survey that simply asks ’select answer X’ could be a way to find out if respondents are taking the survey seriously.

NS panel response bias

The survey was distributed via the NS panel and the respondents were a national representative sample. However, it is important to bear in mind that people in the NS panel actively chose to be a part of it, for example, because they have a strong opinion about it. They are not the average Dutch citizen in terms of travel choice behaviour. Thus, the LCCM results are not directly translatable to the entire Dutch population. For example, 18,1% of the sample is a disliker of trains, not necessarily 18,1% of the potential users. Despite this, these results were still much more valuable than they would have been if the distribution would have had to be done manually.

8.4. Recommendations for future research

Finally, some recommendations for future research will be made. As the available literature on the topic is scarce, there is a lot that can still be studied. Based on the process and findings of this study, some recommendations will be made that showed to have potential.

Attributes

This study included six attributes. Five of them were operational attributes, and one was a service attribute. The selection of these attributes was based on the findings of the literature review and focus groups. However, that does not mean these are the only attributes of influence on choice behaviour. It might be interesting to include others. For example, in the comment section of the survey, multiple respondents have indicated that the exact departure and arrival times are usually also of influence in their choice. Furthermore, in the focus groups, the physical attributes also came forth. This included the exact time and location of the transfer, so that you can for example go into the city for lunch or dinner, but also shelter, level crossings, and other facilities of the station. In this study, it was decided not to include these factors because they are not visible when booking a trip. However, it might be interesting to test whether displaying these attributes while booking can make a transfer more appealing.

Modal substitution

This research was scoped purely on long-distance train travel. The experiment included alternatives with a transfer, one static, transferless base alternative and an opt-out alternative. The latter two were simplifications to keep the research feasible and within its scope. Thus in this research, the transfer alternatives were compared to a very unattractive direct option, and the alternative modes in the opt-out were not specified or varied. Therefore, this experiment only mapped out a portion of the travel choice. It would be very interesting to include more realistic direct trains into the experiment that also vary on each attribute level. However, caution must be taken to avoid the dominance of the transferless alternatives. Furthermore, it could be interesting to look at the modal substitution of trains as opposed to specified other modes. Thus, when increasing the potential of long-distance train travel, does this mainly take away from car travellers, air travellers, or from another mode? These could also be integrated dynamically and vary over different attributes and levels to see the substitution patterns.

Service specification

Service was included in the study as a single attribute. However, it turned out to be a complex variable. You can ask yourself: What is a good service? It comes with various facets, like insurance, refund schemes, customer care, brand image, etc. In the simplified way in which it was incorporated into this research, service did not have a large impact on choice behaviour, which contrasted with the findings of the literature research and focus groups. Therefore, it might be interesting to incorporate service in a more complex manner. This can be done by making several attributes covering the different facets, or it can be incorporated in a hierarchical way. This introduces a second experiment, a rating experiment, where respondents indicate for each facet how much they think it contributes to the service level. In this way, they create a personal interpretation of each service level which can be tested in the main choice experiment. Since service is a very qualitative attribute, by incorporating it in a hierarchical way, it will become easier to quantify.

Choice context

It was chosen to have a single, static choice context in this study. This context includes travel distance (to where), travel motive (what for) and travel company (with whom). However, it might be interesting to see how choice behaviour differs for different choice contexts. This can be done by proposing different contexts to a single respondent or even incorporating them as attributes. Another option to account for the heterogeneity in behaviour between different contexts would be to make it dynamic. At the beginning of the survey, the respondents were asked for their travel motives and travel company of their long-distance trips in the past year. These answers were included as covariates in the model but showed no significant relationship to the class parameter result. Reflecting on this, it might have been interesting to include this dynamically in the survey. This means that their context would be based on their own experience. In this way, respondents can easily put themselves in the scenario because they have travelled in this context more often. This might also make the results more valid and reliable, as the choice task might not exhaust the respondents as much and better resemble a real-world choice situation for a certain respondent.

Incorporating more psychological factors

From all the covariates included in this study, the psychological factors had the most significant relations to the latent class variables. These psychological factors included the respondent's intention to use environmentally friendly means of transportation, the respondent's personal liking for trains and train travel, and whether the respondent is driven by their bad experience with train travel. These were predefined. It might be interesting to include more attitudinal statements and perform an explorative factor analysis to see if more psychological factors can be identified that have a significant relation to the latent classes.

Calculating benefits

Building upon the results of this study, it would be interesting to calculate the exact societal benefits that will result from implementing different policies in actual cases in Europe. This study proposes different policy implications that might have an effect, but the actual monetary effect can be calculated before it is implemented. Where do we lose out, and where do we improve? Does a policy change ultimately result in a positive effect? With these calculations, we can find out to what extent improving transfers in the European rail network will improve the potential of long-distance train travel and what the benefits for society would be. This gives an improved feeling of the results and it can be used to explain the results to policy makers.

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A
Scientific paper

The scientific paper can be found on the next page.

Transfer Towards European Train Travel: A stated choice experiment into the effect of train transfer attributes on long-distance leisure travel choice behaviour

I.M. Roebroeck

Abstract

In response to pressing climate issues, Europe is transitioning towards more sustainable transportation. Despite the potential environmental benefits, train travel often loses out to other modes of transportation in long-distance journeys (300+ km). Based on previous research, transfers seem to have a great impact on the attractiveness of train journeys. This study investigates the effects of different transfer attributes on travel choice behaviour in long-distance leisure trips. Through a combination of a literature review and focus groups, key attributes influencing travellers' itinerary choices were identified and incorporated in a stated choice experiment. The experiment, involving 431 respondents, used a Latent Class Choice Model (LCCM) to analyze preferences and willingness to pay for improvements in transfer attributes. The study finds that travel cost and travel time are of the most importance. The number of transfers and transfer time are less critical but still impactful. The service level has a small impact. When the transfer occurs in the journey is insignificant. Four distinct classes of travellers were identified: Time-Valuing Eco-Advocates (44%), Cost-Sensitive Train Travellers (25%), Train Dislikers (18%), and Transfer-Averse Train Sceptics (13%). The results indicate that reducing travel costs and time should be prioritized over improving transfers to maximize the attractiveness of train travel. However, optimizing transfer time and minimizing the number of transfers will still enhance the appeal for specific traveller classes. By analysing the results, it was found that although direct train services are generally preferred, well-designed transfer options can improve market potential. This does however require significant improvements in the European railway network design and regulations.

Keywords: Long-distance train travel, Train transfers, Transfer attributes, Choice behaviour, Latent class choice model

1. Introduction

When travelling over long distances of 300 kilometres or more, the train is a sustainable travel option as it emits 8 times less CO_2 than travelling by car and 10 times less than travelling by plane. These differences are the biggest on distances below 700 km (Milieu Centraal, nd), like on European level. However, air and car travel are still very popular modes in long-distance trips. Because of its environmental benefits, European authorities, like the European Commission, are advocating for an increase in train usage vis-à-vis other modes (European Commission, 2023). To accomplish this the attractiveness of travelling by train for passengers must be increased. This research focuses on a part of the journey that is a big contributor to the attractiveness of the journey: Making a transfer.

A transit trip typically exists of an access time, witing time, in-vehicle time, transfer time, another in-vehicle time, and egress time (Currie, 2005). While in any of these stages, travellers can perceive time differently from how it is actually spent, affecting the attractiveness of a journey. When travelling by train, factors such as comfort and reliability can also contribute to a better, or worse, time perception. Transfers have a negative effect on the travellers' time perception. Transfer time can have a more than 7 times higher impact on the market share than in-vehicle time, and thus affect the attractiveness of a trip (Gielisse, 2024). Therefore, it can be a reason for travellers not to choose the train. Because of its significant impact on time perception, small improvements in a transfer have the potential to make a great deal of difference in the overall attractiveness of long-distance train travel.

On top of that, the European railway network is expanding over limited infrastructure, making the need for transfers inevitable. Hence, they require a proper design. The transfers are essential for creating a flexible, efficient, and comprehensive network. This is crucial for accommodating the varying travel demand. Transfers also create more travel options for passengers to choose from, accommodating their varying needs and schedules, and making it possible to reach a broader array of destinations. Transfers allow train operators to optimize their timetables and routes ensuring better resource use and higher frequencies while reducing the need for extensive infrastructure development. That is why, although they can be unwanted, transfers are actually needed.

In most existing travel choice models, making a transfer comes with a fixed time penalty. This is a fixed amount of time that is added to the total travel time as a penalty when the journey involves a transfer. These penalties vary widely over studies, from as low as 5 minutes of additional travel time to as high as 20, in short-distance contexts (Van der Waard, 1988; Vrtic and Axhausen, 2002; Bovy et al., 2008; Nielsen, 2004; Nielsen and Frederiksen, 2006; Eluru et al., 2012; de Grange et al., 2012; Nielsen et al., 2021). This wide range is not surprising, considering that every transfer has different characteristics, including the place where the transfer is made, as well as every traveller has different preferences. This paper contribute to the scientific literature by evaluating which attributes of a transfer in long-distance train journeys are most important when a traveller chooses their itinerary and to what extent, while accounting for the differences in preference of travellers. It revolves around the passenger perspective, and aims to increase the attractiveness of long-distance train travel for users.

2. Literature review

The literature on transfers in long-distance train journey is very scarce. Therefore, in this literature review, we first look at studies on transfers in urban transit (short-distance) context. To put this in perspective with long-distance journeys, we review studies on transfers in air travel context. The goal of this review is to identify different transfer attribute types that are interesting to include in this study.

2.1. Transfers in urban transit networks

Some studies have developed models to better estimate transfer parameters and understand transfers. Iseki and Taylor (2009) created a conceptual framework emphasising the importance of considering operational factors and transfer facility attributes. Guo and Wilson (2004) developed a method to improve transfer penalty estimates by incorporating station specifics, environmental effects, and demographic effects. Si et al. (2013) developed an assignment model that accurately reproduces passengers' transfer and route choices.

Other studies focused on unimodal networks. Raveau et al. (2011) incorporated topological variables into models, improving the explanatory and predictive power of route choices. Guo and Wilson (2011) found significant trip costs associated with transfers, varying across locations. Raveau et al. (2014) identified a wide variety of elements influencing route choices in different cities, indicating heterogeneous passenger preferences. Zhu et al. (2021) observed a positive correlation between transfer passenger flow and node degree of transfer stations.

In multimodal network analyses, Navarrete and de Dios Ortúzar (2013) found that multimodal transfers are more heavily penalized by travelers, with walking time being a significant factor. Chen et al. (2022) defined more realistic station catchment areas based on transfer behavior. Schakenbos et al. (2016) identified optimal transfer times based on total travel time distribution. Garcia-Martinez et al. (2018) and Nielsen et al. (2021) estimated transfer penalties, acknowledging differences in passenger preferences. Anderson et al. (2017) modeled route choice behavior considering heterogeneity among travelers.

Studies on transfer reliability included those by Chowdhury and Ceder (2013); Chowdhury et al. (2014), who emphasized the psychological perspective of transfer inconvenience and the importance of information integration. Marra and Corman (2023) found significant effects of network disturbances on travel costs and route choices. Xu et al. (2023) investigated path choice behavior considering travel time variability, highlighting passengers' different risk-aversion attitudes.

2.2. Transfers in air travel

To put these findings in perspective to studies in long-distance context, we looked at some results of studies that modelled passenger choice behaviour in air travel context. Here it is found that air travelers value service attributes such as staff politeness, insurance for missed transfers, and assistance in finding alternative travel options (Burghouwt and Veldhuis, 2006; de Barros et al., 2007; Choi et al., 2019). Competition characteristics, quality branding, frequency, travel time, and airfares also play significant roles (Adler, 2005; Chung et al., 2017; Coldren et al., 2003). However, a direct comparison between air and train transfers cannot be made due to fundamental differences such as security segregation and service provision.

2.3. Transfer attribute types

Within the literature, three types of transfer attributes were identified: physical, operational, and service. Physical attributes include station characteristics such as shelter, stairs, escalators, real-time information, crowding, distances, ramp length, level transfers, amenities, appearance, seats, shop availability, and wayfinding (de Barros et al., 2007; Chowdhury and Ceder, 2013; Chowdhury et al., 2014; Chung et al., 2017; Garcia-Martinez et al., 2018; Guo and Wilson, 2004, 2011; Iseki and Taylor, 2009; Navarrete and de Dios Ortúzar, 2013; Nielsen et al., 2021; Raveau et al., 2011, 2014). Operational attributes include aspects defining the trip itinerary, such as access/egress time, in-vehicle time, waiting time, walking time, number of transfers, and travel costs. These attributes are included in every study in the review. Service attributes enhance travel quality through reliability, comfort, security, safety, delay probability, alliance membership, employee service, and insurance (Iseki and Taylor, 2009; Nielsen et al., 2021; Chowdhury and Ceder, 2013; Xu et al., 2023; Adler, 2005; Burghouwt and Veldhuis, 2006; de Barros et al., 2007; Choi et al., 2019; Chung et al., 2017; Coldren et al., 2003).

In urban contexts, time attributes (waiting, walking, in-vehicle) are crucial, with physical attributes also being important when included in studies. Service attributes, particularly reliability, are significant but less frequently included. In long-distance air travel, service attributes are predominant. This suggests that potentially interesting transfer attribute types in long-distance train travel are within operational and service attributes. The heterogeneity among travellers is prominently highlighted in the existing literature. Therefore, it is interesting to take this into account in the model.

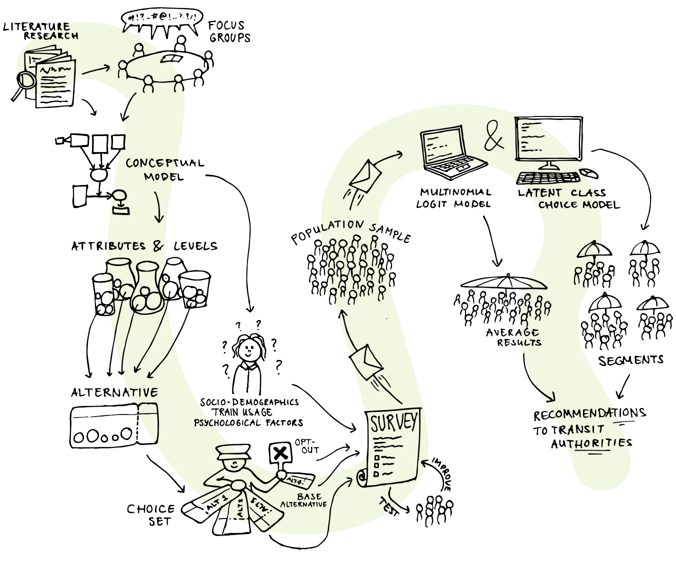

Figure 1: Method flow

3. Methodology

Figure 1 shows the method flow of the study. The findings from the literature research were further explored in a focus group study, which was conducted according to the guidelines of Krueger and Casey (2014). These findings formed the conceptual model (section 4), which was used as the basis of the stated choice survey. The results were analysed using discrete choice modelling, specifically a multinomial logit (MNL) model and a latent class choice model (LCCM).

3.1. Stated Choice survey

To quantify parameters that resemble preferences for different attributes, data is gathered with a Stated Choice (SC) survey. This method is very well-suited for cases where participants cannot be confronted with choices in real life. In an SC survey, participants are presented with several travel alternatives, and asked to choose one. Modelling these choices can later establish parameters for all attributes included in the alternatives.

The choice context was chosen to be long-distance journeys between 700 and 850 km, like for example Amsterdam to Munchen, Basel, or Lyon. At this distance, train travel is competitive with air travel (Adler et al., 2010), and can have a significant market share (Donners, 2016). Furthermore, direct trains hardly exist on these distances, making transfers inevitable and feel natural to travellers. Moreover, respondents were asked to imagine they are travelling for leisure purposes. This was chosen because leisure purposes form the biggest proportion of all long-distance trip purposes (LaMondia and Bhat, 2012; Davis et al., 2018). 91 % of the sample indicated that most of their long-distance travel has been for leisure purposes. They were also asked to imagine they were travelling alone, to relieve respondents of any travel complications, only consider their personal preferences, and rely on their own knowledge and capabilities.

The choice alternatives in the survey were constructed using an orthogonal design to ensure that the correlations between the attributes are zero. The choice tasks were constructed sequentially, meaning that the alternatives were randomly placed into the choice sets after the alternatives were constructed. This was applied because there are only generic attributes and each alternative has the same attributes and attribute level variation. Each choice task included three alternatives.

In the survey, respondents chose between alternatives, followed by a base transferless option to contextualize their initial choice. This helped evaluate the potential of incorporating good transfers in a train network over scheduling numerous direct trains, which benefits infrastructure occupancy and overall network efficiency. Respondents were then asked if they would travel by train considering all the given options, allowing assessment of the European train network's potential.

The survey was constructed using the NGene software package, and distributed via the NS panel. This is a group of people who have volunteered to participate in different studies about train travel in the Netherlands. Using the NS panel enables us to recruit sufficient participants in a nationally representative sample.

3.2. Discrete Choice modelling

With discrete choice modelling, you can explain the choices made by individuals and predict choice behaviour. It is based on the principle of random utility maximisation (RUM) (McFadden, 1972). This principle assumes that people will always choose the option that bring them the highest utility (U). This utility can be split into a deterministic part (V) and ab error term (ϵ) and is described by:

$$U_i = V_i + \epsilon_i \tag{1}$$

The deterministic component of the alternative is described by the weighted sum of all attribute values. Therefore, the utility of alternative i can be described as shown in equation 2.

$$U_i = \sum_m \beta_m \cdot x_{im} + \epsilon_i \tag{2}$$

Where i are the alternatives, m are the attributes, x are the attribute values, β are the weights or tastes to be estimated, and ϵ is the random error.

3.2.1. Multinomial logit model

The data from the SC survey will first be modelled in a Multinomial Logit (MNL) model, to estimate average results of the entire sample. An MNL model assumes that each alternative has an observed utility and a random, identically, and independently distributed error term. It yields the set of parameters that is most likely to result in the observed sample. The probability that an individual makes choice i is described by:

$$P(i) = \frac{exp(\sum_m \beta_m \cdot x_{im})}{\sum_{j \in J} exp(\sum_m \beta_m \cdot x_{jm})} \quad (3)$$

Where J is the set of all alternatives that also includes alternative i (Chorus, 2021).

3.2.2. Latent class choice model

To account for the differences in preference between respondents, an Latent Class Choice Model (LCCM) is estimated next. An LCCM separates the sample into classes and estimates class-specific parameters. It uses a class-membership function to model to which class an individual belongs. The probability of observing a choice is assumed to be a weighted sum of choice probabilities across all classes, as shown in equation 4.

$$P_n(i|\beta) = \sum_{s \in S} \pi_{ns} \cdot P_n(i|\beta_s) \quad (4)$$

In this equation, π_{ns} is the probability that individual n belongs to class s, and $P_n(i|\beta_s)$ is the class specific choice probability of choosing alternative i. An LCCM overcomes the limitations of a RUM model since its substitution patterns are not proportional and heterogeneity amongst individuals is accounted for (Hernandez, 2023). π_{ns} can be described as:

$$\pi_{ns} = \frac{exp(r_{ns})}{\sum_{l \in S} exp(r_{nl})}, \quad r_{ns} = \delta_s + \sum_{q \in Q} \gamma_{sq} z_{nq} \quad (5)$$

This equation indicates that the class membership probability is influenced by socio-demographic parameters. δ and γ are the class membership parameters, and z are the socio-demographic parameters (Hernandez, 2023).

4. Conceptual model

To form a conceptual model, a focus group study was executed based on the findings of the literature review (section 2). Following the guidelines of Krueger and Casey (2014), a questioning route was formulated. Two focus groups were conducted to identify specific attributes to include in the survey and covariates that might influence choice behaviour. The conceptual model is shown in figure 2.

Six attributes were identified. The travel costs were included as they seem to play a significant role in decision making, and make it possible to calculate the willingness to pay (WTP) for all other attributes. Three types of time attributes were included. First the travel time, which is the time a travellers spends in the train before reaching the destination. This is varied to be either 8, 10, or 12 hours. The transfer time is the time between the arrival of a train and the departure of its succeeding train in the itinerary, and varied at 5, 20, 35 and 50 minutes. Finally, time distribution is included. This denotes how the separate travel times of each train are distributed over a journey, and at what point in the journey a transfer takes place. This is varied to be either evenly distributed, or unevenly distributed with the transfer(s) either in the beginning or the end of the journey. The number of transfers is also included and varied at 1 or 2 transfers, as well as a service attribute which indicates the level of service that comes with the ride. This attribute is varied at light, standard, and premium service, which include different gradations of refund schemes, flexible travel times and seat assignments.

Besides the socio-demographics, two other types of covariates were identified that might influence choice behaviour. The first are some psychological factors. These represent travellers attitudes towards long-distance train travel on certain fronts. The three factors that were included are a person's intention to use environmentally friendly means of transportation, a person's personal liking of trains and train travel, and to what extent a person is driven by bad experience with train travel. These factors were measured with a factor analysis. The survey included several statements regarding these factors of which a respondent had to indicate to what extent they agreed with it. The factor analysis resulted in factor scores per factor per respondent. On top of the psychological factors, the respondent's train usage was also found to be a potential influencing factor. This was split into a person's general (domestic) train usage, the number of long-distance trips they made in the past year, the number of long-distance trips they made by train in the past year, their general travel motive (business or leisure) and their general travel company (alone, with a partner, friends, family, colleagues, etc).

5. Specification

The survey was specified in several parts. After a short introduction into the research and the topic, the respondents were first asked about their train usage. These were easy to answer questions since they asked for facts. Thereafter, the respondents are introduced to the setup of the choice experiment and the visualisation of the alternatives was explained. Next came the actual choice experiment. Figure 3 shows an example of how the choice sets were presented to the respondents. As the respondents are all Dutch, the design was based upon the Dutch train planner apps of NS and 9292. This made the choice task easy to interpret.

As discussed in the methodology, the respondents first choose between the three alternatives in the choice set, after which they compare their chosen travel option to a transferless base alternative. The goal of this second choice task (transfer vs. no transfer) was to determine if respondents would prefer a 'good' transfer trip over a direct trip. The base alternative was set to the worst levels (110 euros, 12 hours, light service) to ensure it is not dominant. This setup helped identify the importance of each attribute (cost, time, service) in making a transfer trip acceptable and highlighted the transfer aversion among different respondent classes through alternative specific constant (ASC) estimates. Figure 4 shows how the base

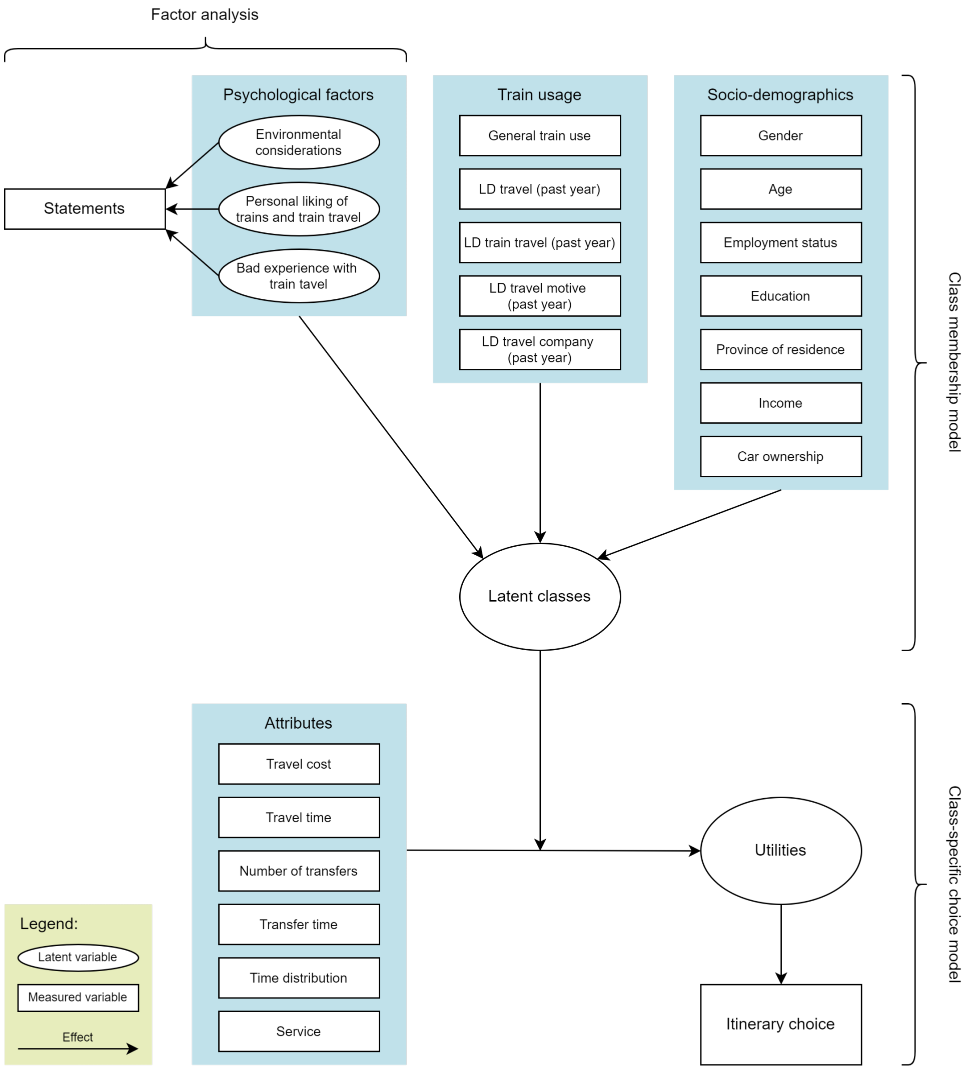

Figure 2: Conceptual model

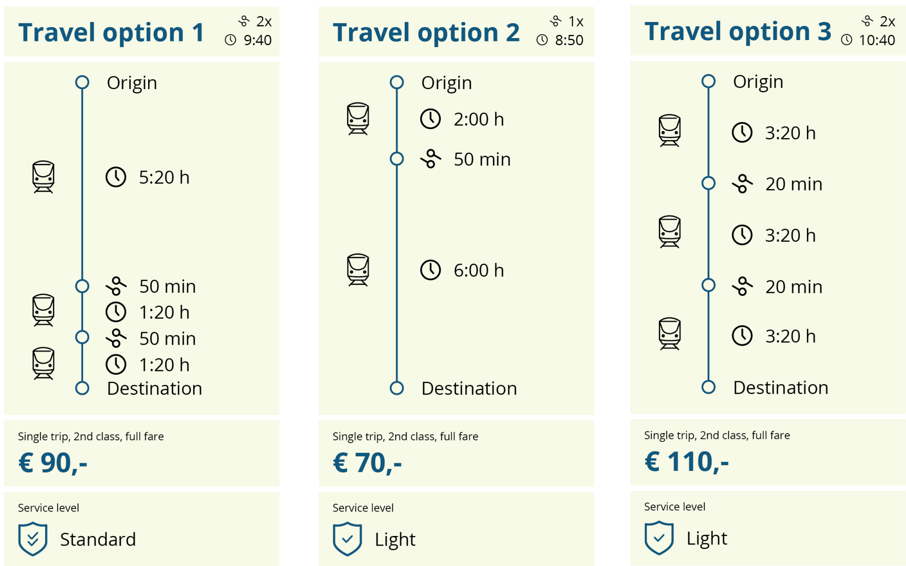

Figure 3: Example of a choice task

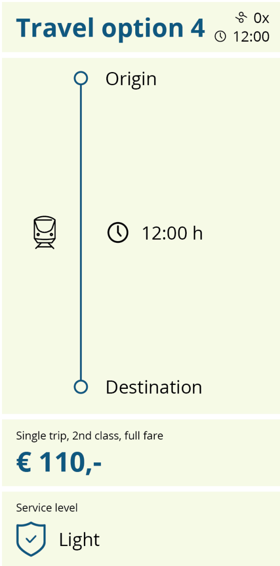

Figure 4: Base alternative

Table 1: Parameter estimates MNL

Attributes		**Estimate**	**z-value**
Travel cost		**-3,70**	-21,83
Transfer time		**4,77**	9,55
Transfer time squared		**-4,57**	-8,77
Travel time		**-4,29**	-25,62
Number of transfers		**-1,10**	-21,26
Time distribution	Even	0,01	0,14
	UnevenLS	-0,03	-0,89
	UnevenSL	0,03	0,76
service	Light	**-0,21**	-5,89
	Standard	0,01	0,13
	Premium	**0,21**	5,71
ASC no transfer		**1,31**	8,02
ASC opt-out		**-8,01**	-34,41

alternative was presented in the survey.

As final part of the choice task, respondents were asked if, given the travel options, they would choose to travel by train or opt for another mode like car or plane. This question helped provide a complete picture of travel preferences, contextualised previous choices, and identified respondents who strongly dislike trains. An alternative specific constant (ASC) for the opt-out option was estimated, indicating which respondent classes are more opposed to train travel and was used in the calculation of hypothetical market shares for train travel versus other modes. The three questions (choose between transfer alternatives, choose between initial choice and base alternative, opt-out) were asked separately to prevent dominance from the base and opt-out alternative, which would make the parameter estimations of the transfer attributes less reliable. In the end, this turned out not to be the case and all five alternatives were considered in one model. This setup also helped guiding the respondent though the options.

After the choice experiment, the respondents were presented with 12 statements for the psychological factor analysis. This was done after the choice experiment to keep it unbiased. Finally, the respondents were asked about their socio-demographic characteristics, and had the opportunity to leave comments.

In the specification of the model, the numeric attributes were scaled to obtain parameter estimates in the same order of magnitude. This way, no information was lost when rounding the estimates. Travel cost and travel time were scaled down a factor 10, and transfer time was expressed in hours. The nominal variables were effects coded, meaning one level's estimate is the negative sum of the other two, and an estimate indicates the difference from the mean utility contribution of the attribute (since the mean of the three is 0). Nominal covariates were aggregated into a maximum of four levels to maintain anonymity of respondents and simplify the model.

Non-linearity was assumed for the transfer time attribute, so a quadratic component was added to the attributes and utility functions, revealing that this component was statistically significant. The utility contributions of transfer time levels differed significantly between the linear and non-linear approaches, leading to the decision to code transfer time quadratically.

The models were estimated in Latent GOLD, which includes a function that picks random starting values and chooses the one that leads to the highest log-likelihood value, making sure it the model will not get stuck in a local optimum but finds the actual optimum. It also calculates the Bayesian Information Criterion (BIC) for different LCCMs to establish which model has the most optimal ratio between a high log-likelihood while maintaining a low number of parameters. The 5-class model had the best BIC value, but did not provide any additional information over the 4-class model. Therefore, the 4-class model was interpreted.

6. Results

6.1. MNL

First, an MNL model was estimated. Table 1 shows the parameter estimates. The right column denotes the z-value, which is similar to the t-statistic, meaning an estimate is statistically significant when the absolute z-value is 1.96 or above. Significant estimates are printed in bold.

A few observations can be made. Travel cost has a significant negative effect on the utility of an alternative. Transfer time has a significant quadratic effect with a preferred optimum of about 31 minutes. Travel time has a significant negative effect on the utility of an alternative. The number of transfers has a significant negative effect on the utility of an alternative.

Table 2: WTP for attribute level increases

Attribute	Level increase	WTP
Transfer time	5 - 20 min	€ 19,35
	20 - 35 min	€ 3,89
	35 - 50 min	€ -11,57
Travel time	+ 2 hours	€ -23,18
Number of transfers	1 - 2	€ -29,75
Time distribution	unevenLS - even	€ 1,03
	even - unevenSL	€ 0,60
Service	light - standard	€ 5,87
	standard - premium	€ 5,47

Time distribution does not have a significant effect on the utilities. A light service level has a significant negative effect on the utilities and a premium service level has a significant positive effect on the utilities. The estimate of the standard service is not significant. Since it is effects coded, this means it has an average utility contribution. The estimates of the ASCs of the base and opt-out alternatives are also significant. This cannot directly be interpreted as intrinsic preferences since they contain different attributes. However, the ASC of the base alternative can be corrected since its attribute values are known. This leads to a negative systematic utility difference, indicating a base preference for direct journeys.

The relative importance of each attribute was calculated with the maximum utility difference. In the context of the study, travel cost (34%) and travel time (27%) are considered relatively most important. Transfer time (13%) and the number of transfers (17%) are a little less important, and service (7%) is the least important. The average willingness to pay (WTP) for each attribute level increase is shown in table 2. The average value of time (VoT) is found to be €11,59. The average WTP for one transfer instead of two is almost €30. Considering the VoT, this corresponds to 2,5 hours of additional travel time. The average WTP for a service upgrade from light to medium is €11,34, which corresponds to almost one hour of additional travel time.

6.2. LCCM

To account for the heterogeneity in the population, 4 latent classes were estimated and interpreted. They are visually represented in figure 5. The parameter estimates are shown in table 4. The differences between the classes become clear when looking at the relative importance of attributes per class in figure 6. It is important to note that this relative importance is not absolute but also relative to the selected attribute level variance in this experiment. A smaller variance in attribute levels would automatically lead to a smaller utility difference, and a lesser importance. Yet, these values are presented since the level variance in the experiment is based on real-life examples. Finally, the willingness to pay for each attribute level increase per class is shown in table 3.

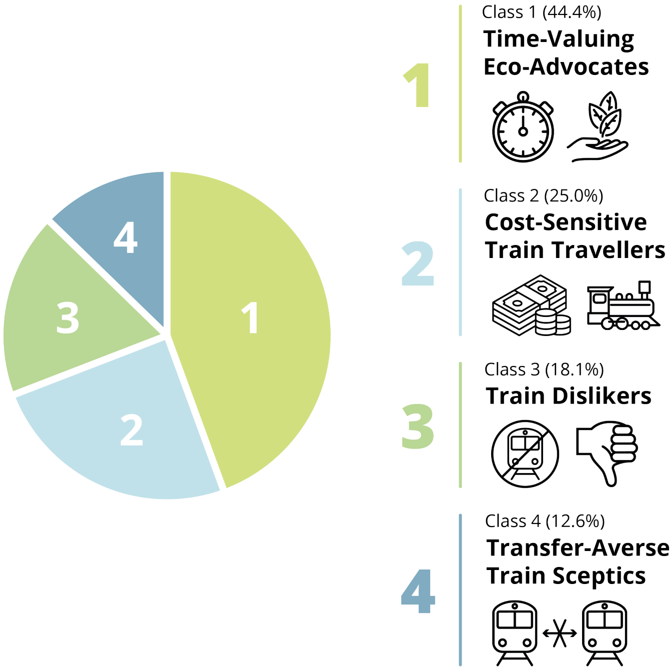

Figure 5: Latent classes

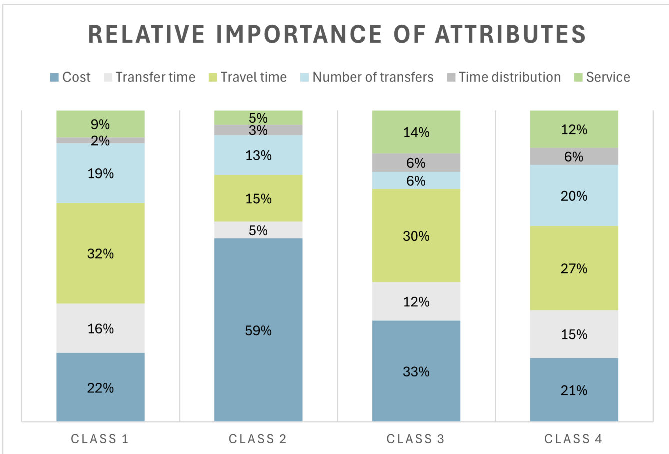

Figure 6: Relative importance of attributes per class

Table 3: WTP for attribute level increases per class

		Class 1	*Class 2*	*Class 3*	*Class 4*
Attribute	**Level increase**	**WTP**	**WTP**	**WTP**	**WTP**
Transfer time	5 - 20 min	€ 33,94	€ 4,18	€ 8,64	€ 29,42
	20 - 35 min	€ 7,14	€ 1,26	€ -4,61	€ 14,44
	35 - 50 min	€ -15,36	€ -1,67	€ -17,87	€ -0,54
Travel time	+1 hour (VoT)	€ -22,04	€ -3,85	€ -13,75	€ -19,19
	+ 2 hours	€ -44,07	€ -7,71	€ -27,49	€ -38,37
Number of transfers	1 - 2	€ -52,37	€ -13,08	€ -10,18	€ -55,91
Time distribution	unevenLS - even	€ -2,16	€ 2,10	€ 3,53	€ -9,37
	even - unevenSL	€ -2,87	€ -3,41	€ 7,48	€ 16,74
Service	light - standard	€ 13,34	€ 3,41	€ 13,25	€ 33,33
	standard - premium	€ 9,84	€ 1,29	€ 12,04	€ -2,40

Table 4: Parameter estimates LCCM

		Class 1: Time-Valuing Eco-Advocates		*Class 2: Cost-Sensitive Train Travellers*		*Class 3: Train Dislikers*		*Class 4: Transfer-Averse Train Sceptics*	
Attributes		**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**
cost		**-3,21**	-9,76	**-8,58**	-13,04	**-3,48**	-4,74	**-2,99**	-3,62
transfertime		**7,00**	8,02	2,27	1,80	2,74	1,35	**5,01**	2,05
sq_transfertime		**-6,33**	-7,10	-2,01	-1,55	-3,69	-1,65	-3,58	-1,47
totaltraveltime		**-7,08**	-18,96	**-3,31**	-7,06	**-4,78**	-5,97	**-5,73**	-5,92
numberoftransfers		**-1,68**	-17,84	**-1,12**	-8,52	-0,35	-1,53	**-1,67**	-6,03
distribution	even	0,01	0,12	0,16	1,87	-0,05	-0,26	-0,26	-1,37
	unevenLS	0,08	1,27	-0,02	-0,27	-0,17	-1,00	0,02	0,11
	unevenSL	-0,08	-1,33	-0,13	-1,49	0,21	1,31	0,24	1,38
service	light	**-0,39**	-5,55	**-0,23**	-2,75	**-0,45**	-2,40	**-0,64**	-2,92
	premium	**0,35**	5,38	0,17	1,86	**0,43**	2,91	0,28	1,54
	standard	0,04	0,58	0,06	0,64	0,01	0,08	0,36	1,92
notransfer		**1,06**	3,74	0,27	0,65	1,21	1,42	**4,26**	4,66
nopick		**-12,77**	-24,21	**-14,35**	-16,16	**-4,67**	-4,88	**-9,64**	-8,24

	Class 1		*Class 2*		*Class 3*		*Class 4*	
Intercept	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**
	0,87	1,26	0,12	0,16	1,20	1,56	-2,19	-1,31

		Class 1		*Class 2*		*Class 3*		*Class 4*	
Covariates		**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**	**Estimate**	**z-value**
ENVIRONMENT		**0,28**	2,19	0,26	1,72	**-0,46**	-3,10	-0,08	-0,46
EXPERIENCE		-0,19	-1,50	**-0,42**	-2,73	**0,28**	1,96	**0,34**	2,00
LIKING		0,06	0,43	0,04	0,27	**-0,35**	-2,27	0,25	1,32
PROVINCE	Other	-0,02	-0,25	0,15	1,22	0,06	0,53	-0,18	-1,32
	Randstad	0,02	0,25	-0,15	-1,22	-0,06	-0,53	0,18	1,32
INCOME	High	0,04	0,20	-0,38	-1,49	0,09	0,35	0,25	0,95
	Low	-0,32	-1,23	**0,52**	2,06	0,26	0,94	-0,45	-1,16
	Mid	0,15	0,97	-0,09	-0,49	0,02	0,11	-0,08	-0,37
	Unknown	0,13	0,76	-0,05	-0,23	-0,36	-1,63	0,28	1,15
CARS	No	0,01	0,12	0,12	1,00	-0,15	-1,21	0,02	0,14
	Yes	-0,01	-0,12	-0,12	-1,00	0,15	1,21	-0,02	-0,14
GENDER	Female	0,13	1,34	**-0,38**	-2,94	0,14	1,16	0,10	0,78
	Other	-0,13	-1,34	**0,38**	2,94	-0,14	-1,16	-0,10	-0,78
AGE		0,00	0,07	0,01	1,15	-0,02	-1,56	0,00	0,35
TRAINUSE	Often	0,01	0,13	-0,13	-1,10	-0,06	-0,46	0,18	1,28
	Seldom	-0,01	-0,13	0,13	1,10	0,06	0,46	-0,18	-1,28
WORKSTATUS	Other	-1,18	-1,84	-0,58	-0,93	0,09	0,15	1,67	1,04
	Retired	-0,33	-0,55	-0,72	-1,13	-0,78	-1,21	1,84	1,14
	Student	1,01	0,66	0,77	0,50	0,76	0,49	-2,54	-0,57
	Unknown	0,93	0,60	1,04	0,67	0,50	0,32	-2,47	-0,54
	Working	-0,43	-0,78	-0,51	-0,91	-0,57	-1,01	1,50	0,96
EDUCATION	High	0,22	1,81	-0,18	-1,34	-0,05	-0,40	0,02	0,10
	Low	-0,22	-1,81	0,18	1,34	0,05	0,40	-0,02	-0,10
LD_TRAVEL	Often	-0,21	-1,69	-0,04	-0,28	**0,38**	2,23	-0,13	-0,78
	Seldom	0,21	1,69	0,04	0,28	**-0,38**	-2,23	0,13	0,78
LD_TRAIN	Never	-0,05	-0,38	-0,22	-1,52	**0,50**	3,13	-0,23	-1,36
	Yes	0,05	0,38	0,22	1,52	**-0,50**	-3,13	0,23	1,36
MOTIVE	Business	-0,29	-1,52	-0,06	-0,29	0,37	1,66	-0,02	-0,06
	Leisure	0,29	1,52	0,06	0,29	-0,37	-1,66	0,02	0,06
COMPANY	Alone	0,11	0,58	0,08	0,34	-0,09	-0,33	-0,10	-0,39
	Other	0,02	0,09	-0,02	-0,09	-0,11	-0,51	0,12	0,54
	Partner	-0,13	-0,72	-0,06	-0,27	0,20	0,88	-0,01	-0,06

6.2.1. Class 1: Time-valuing eco-advocates (44.4%)

Class 1 is the largest class in the sample and is characterised by its high VoT. They prefer to arrive at their destination quickly. They are also sensitive to transfer time and the optimal transfer time lies around 33 minutes. However, they prefer to avoid this since they are somewhat transfer-averse. Someone who has a high intention to use environmentally friendly modes is more likely to belong to this class. Since this is the largest class, the population sample (the NS panel) contains a lot of environmentally conscious people.

6.2.2. Class 2: Cost-sensitive train travellers (25.0%)

Above all else, class 2 is very driven by costs. They are willing to compromise on a lot of fronts if it means they can reduce the costs of the travel. They are not time-sensitive, nor are they very opposed to making a transfer. However, they do like to travel by train and will not quickly choose another mode of transportation. Someone who is not driven by bad experiences with train travel is more likely to belong to this class. Also, in line with their cost sensitivity, people with lower incomes are more likely to belong to this class. Class 2 is the second largest class and accounts for about a quarter of the population sample.

6.2.3. Class 3: Train dislikers (18.1%)

A significant portion of respondents from the NS panel are not big fans of long-distance train travel, and express their criticism. Class 3 accounts for over 18% of the population sample. They are likely to be indifferent to the number of transfers and transfer time, but value a good service. This aligns with the finding that they are most likely to opt for another mode over train travel. A person is likely to belong to this class when they have often travelled over long distances in the past year, but never by train. They are likely to have no intention to use environmentally friendly modes, to be driven by bad experiences with train travel and not to have a personal liking for trains and train travel.

6.2.4. Class 4: Transfer-averse train sceptics (12.6%)

The final class, class 4, definitely does not like to make a transfer. They are most likely to opt for a transferless alternative and are very sensitive to additional transfers. Class 4 is the least cost-sensitive class and is therefore willing to pay for conveniences like fewer transfers, but also to avoid bad service. When making a transfer is inevitable, this class prefers a high transfer time. People in class 4 are also somewhat likely to opt for other modes of transportation over train travel. This is reflected in the fact that a person who is driven by their bad experiences with train travel is likely to belong to this class.

7. Conclusion and discussion

This study estimates the effect of train transfer-related attributes on travel choice behaviour in long-distance leisure journeys. It analyses the results from a Stated Choice experiment. In total, 431 complete surveys were collected in May 2024 from a Dutch nationally representative sample.

This study first applied literature and focus group research to identify relevant attributes and other factors to include in the model. It was found that operational and service transfer attributes seem most likely to influence long-distance travel choice behaviour. The findings of the qualitative focus group study were in line with those of the literature research, which specified the operational and service attributes to include.

Next, a stated choice experiment was conducted. The data was first analysed in a multinomial logit (MNL) model. Here, it was that overall, transfers are less important determinants in the travel choice than travel cost and travel time. On one hand, this implies that improvements specific to transfers will not have a big impact on travel behaviour unless these enhancements lead to overall reductions in travel time and costs. On the other hand, this is favourable news for network designers as transfers are regarded as less critical. Reducing travel times and costs should be their priority, making it less concerning if there are few transfers involved. However, transfers are still important and contribute to the comfort of the journey, so they cannot be neglected. The service level was found to have a relatively small impact on the attractiveness of the alternative. This is in contrast with the expectations. Improving the service of train travel seems to not have a great impact on the potential of long-distance train travel. However, this attribute was simplified and quantified for this research, while in reality, it is a very complex and qualitative attribute. It might be interesting to incorporate this in future studies. This can be done by making several attributes covering the different facets of service, or it can be incorporated in a hierarchical way. Since service is a very qualitative attribute, by incorporating it hierarchically, it will become easier to quantify. The time distribution, denoting the difference in travel times of the separate trains in the journey, was found to be an insignificant attribute. This means that travellers do not have a distinct preference for their transfers to be at the beginning of their journey, at the end of their journey, or evenly distributed over their journey. Therefore, this does not need to be considered in network design or policy making.

On top of this general MNL approach, this study also estimated a latent class choice model (LCCM) on the SC data. Four latent classes were identified in the population sample. These are internally homogeneous, meaning that people within the class exhibit similar choice behaviour. It was found that some people prefer to travel by train, but another group of people is very unwilling to travel by train and very hard to persuade. Another part is open to the idea but encounters obstacles. For one class the main obstacle is the ticket prices, and for another class this is transfers. Here lies the sweet spot for improvements leading to increased potential of trains. Improvements in these areas can sway these classes to choose the train over other modes. Marketing about the improvements can be specifically targeted at these groups of travellers, increasing the demand.

The implementation of good transfers might benefit from more European cooperation, alliances, or even a unified European transit government. Currently, there are strong national concerns about train travel, as it relies on national subsidies. There is limited infrastructure available and there are concessions. Improving the cooperation on a European level will result in a more unified network that meets the needs of travellers and ensures that a traveller is not left to fend for themselves.

All in all, a good transfer should ensure a quick connection while keeping travel costs low. The amount of transfers in a journey should be minimised, and the transfer time should ideally lie between 22 and 42 minutes. A better service can also contribute, although it is expected to contribute less. We hope that the findings of this study can support the market positioning of train travel and the further development of attractive and viable long-distance train networks.

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B

Dutch questioning route Focus group

Table B.1: Dutch questioning route

Nr	Vraag	Antwoord	Tijd
1	Wat is je naam, wanneer reisde je voor het laatst met de trein over lange afstand, waar reisde je naartoe en wat ging je daar doen?	Iedereen afgaan	5 min
2	Wat is het eerste dat in je opkomt als je denkt aan langeafstandsreizen per trein?	Roepen	5 min
3	Teken een flowchart of diagram van hoe een langeafstandstreinreis eruitziet. Kun je uitleggen wat je hebt getekend?	Eerst tekenen in stilte, dan iedereen afgaan	5 min + 5 min
4	Wat zijn de voordelen van reizen per trein ten opzichte van andere vervoerswijzen?	Roepen	10 min
5	Waar maak je je zorgen over als je met de trein over lange afstanden reist?	Roepen	10 min
6	Maak een lijst van alle factoren die je in overweging neemt bij het boeken van een treinreis over lange afstand met een overstap. Kun je uitleggen wat je hebt genoemd?	Mentimeter + alle woorden afgaan	5 min + 10 min
7	(Vervolg) Welke van de factoren op het scherm is het belangrijkst?	Iedereen afgaan	5 min
8	Hoe ziet de best mogelijke transfer voor een langeafstandsreis eruit?	Beurt uitdelen	10 min
9	Alles bij elkaar genomen (All things considered), wat zijn de belangrijkste factoren die je in overweging neemt bij het kiezen van een transferroute?	Beurt uitdelen	5 min
10	Hebben we iets gemist? Is er iets waar we het over hadden moeten hebben, maar niet hebben gedaan? Is er iets dat je wilde zeggen maar niet hebt kunnen zeggen?	Beurt uitdelen	10 min

C

Focus group preparation survey

Focus group participants form

Dear reader,

Thank you very much for participating in this focus group, which will be held on wednesday, 27th of march between 10:30 and 12:30 (we will probably finish a earlier) in the faculty of Civil Engineering and Geosciences, Room-23.HG4.01.1 (DiTTlab). The focus group is part of my graduation research about transfers in long-distance train journeys. The information you provide in this form will be used for three causes: It will give an understanding of who participated in the focus group and potentially identify limitations, it will prepare you for the session, and it will be a first pilot of what personal information might be relevant for my big survey. Thank you in advance for filling it out. If you have any questions, feel free to contact me!

Note: Although this form is in English, the focus group session will be held in Dutch.

Best wishes,
Ines Roebroeck
0618094980
ines.roebroeck@rhdhv.com

* Verplichte vraag

1. **Please confirm you are available at the moment of the session (27/3 10:30-12:30).** *

Markeer slechts één ovaal.

- Yes, I am available

Sociodemographic information

In this section, I will ask you about your sociodemographic characteristics. These are used to analyse data and possibly find trends in specific population segments.

2. **What is your gender?** *

Markeer slechts één ovaal.

- Female
- Male
- Non-binary
- Prefer not to say

3. **What is your age?** *

Markeer slechts één ovaal.

- Younger than 18 years
- 18-29 years
- 30-39 years
- 40-49 years
- 50-59 years
- 60-69 years
- 70 years or older
- Prefer not to say

4. **What is your current employment status?** *

Markeer slechts één ovaal.

- Full-time employed
- Part-time employed
- Unemployed
- Student
- Retired
- Unable to work (arbeidsongeschikt)
- Prefer not to say
- Anders: ______

5. **What is the highest level of education you have completed? (or equivalent)** *

Markeer slechts één ovaal.

- No education
- Primary school
- High school
- MBO
- HBO
- WO bachelor
- WO master
- Doctorate
- Prefer not to say

6. **In which province do you live?** *

Markeer slechts één ovaal.

- Drenthe
- Flevoland
- Fryslân
- Gelderland
- Groningen
- Limburg
- Noord-Brabant
- Noord-Holland
- Overijssel
- Zuid-Holland
- Zeeland
- I do not live in the Netherlands
- Prefer not to say

7. **What is your marital status?** *

Markeer slechts één ovaal.

- Single
- In a relationship
- Married
- Separated
- Divorced
- Widowed
- Prefer not to say
- Anders: ______

8. **How many cars (or motorbikes or similar motorised vehicles, no speed limit) are available to you on a daily basis?**

Markeer slechts één ovaal.

- 0
- 1
- 2
- 3 or more

Attitude

In this section, you will be asked about your attitude towards certain topics.

9. **Please indicate for each statement how much you agree with it. ***

Markeer slechts één ovaal per rij.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am environmentally concious and act accordingly.	⬭	⬭	⬭	⬭	⬭
My time is valuable.	⬭	⬭	⬭	⬭	⬭
Money plays a big role in every choice I make.	⬭	⬭	⬭	⬭	⬭
I usually thoroughly overthink my options before I make any travel decisions.	⬭	⬭	⬭	⬭	⬭
I enjoy travelling by train.	⬭	⬭	⬭	⬭	⬭
I usually feel safe in a train station.	⬭	⬭	⬭	⬭	⬭
When something is too complicated, I easily give up trying.	⬭	⬭	⬭	⬭	⬭
I value comfort and am willing to pay for it.	⬭	⬭	⬭	⬭	⬭
I am usually stressed about making my transfer when I travel by train	⬭	⬭	⬭	⬭	⬭
I would rather make a longer trip if it avoids making a transfer	⬭	⬭	⬭	⬭	⬭

Travel behaviour

In this final section, you will be asked about your travel behaviour.

10. **How often do you travel by train? ***

Markeer slechts één ovaal.

- Never
- Less than once a year
- Once a year
- A few times per year
- Once a month
- A few times per month
- Once a week
- A few times per week
- Every other day
- Every day

11. **How many long-distance trips (300+ km) did you make in the past year? ***

Markeer slechts één ovaal.

- None
- 1-3
- 4-6
- 7-9
- 10 or more

12. **How many of this trips did you make by train? ***

____

13. **What was/were the motive(s) for your long-distance trip(s)? ***

Vink alle toepasselijke opties aan.

- I did not travel long-distance
- Commute (woon-werk)
- Business related travel
- Services/caregiving
- Shopping
- Education or childcare
- Holiday
- Visiting someone
- Sport, hobby, horeca
- Touring (travelling for the sake of the trip)
- Anders: _______________

14. **Who did you travel with on your long-distance trip(s)? ***

Vink alle toepasselijke opties aan.

- Alone
- With a partner
- With friend(s)
- With family
- With collegue(s)
- I did not travel long-distance
- Anders: _______________

15. **What is your prefered mode for long-distance (300+ km) trips? ***

Markeer slechts één ovaal.

- Car
- Train
- Airplane
- Bus
- Bicycle
- Motorbike
- Boat
- Anders: _______________

16. **Why? Please elaborate on the previous question. ***

____

____

____

Focus group preparation

Finally, I want to ask you to perform some preparation for the focus group. to help the discussion along and not waste too much time on thinking. Please allready think about the following question:

When planning a long-distance train trip (300+ km) that includes a transfer, what do you pay particular attention to and based on what factors do you make your itinerary choice?

You can write down some keywords and bring them to the focus group session, or simply just think about it in advance. Please DON'T discuss your answers with other focus group participants in advance, as this discussion is the exact purpose of the session.

Thank you very much for participating, and I look forward to hearing all your insights!

D

Ngene code

```
? Orthogonal design for itinerary choice experiment
design
;alts = alt1,alt2,alt3
;rows = 36
;block = 4
;orth = seq
;model:
U(alt1)=
co*Cost[50,70,90,110]
+t_transfer*TransferTime[5,20,35,50]
+t_total*TotalTravelTime[8,10,12]
+aot*AmountOfTransfers[1,2]
+di*Distribution[0,1,2]
+se*Service[0,1,2]/
U(alt2)=
co*Cost[50,70,90,110]
+t_transfer*TransferTime[5,20,35,50]
+t_total*TotalTravelTime[8,10,12]
+aot*AmountOfTransfers[1,2]
+di*Distribution[0,1,2]
+se*Service[0,1,2]/
U(alt3)=
co*Cost[50,70,90,110]
+t_transfer*TransferTime[5,20,35,50]
+t_total*TotalTravelTime[8,10,12]
+aot*AmountOfTransfers[1,2]
+di*Distribution[0,1,2]
+se*Service[0,1,2]
$
```

E

Survey

As the survey will be distributed among Dutch respondents, it will be entirely in Dutch.

E.1. Introductory text

Beste lezer,

Hartelijk dank voor uw deelname aan dit onderzoek.

Het doel van dit onderzoek is om meer inzicht te krijgen in de afwegingen die reizigers maken wanneer zij kiezen voor een langeafstand treinreis met een overstap. Het zal ongeveer 30 minuten duren om deze enquête in te vullen. De gegevens uit de enquete zullen worden gebruikt om een model te maken waarmee reiskeuzegedrag beter voorspeld kan worden.

Deze enquête is volledig anoniem. Door op volgende te klikken geeft u toestemming dat de door u gegeven antwoorden gebruikt mogen worden in het onderzoek.

Nogmaals ontzettend bedankt voor het invullen.

Met vriendelijke groeten,
Ines Roebroeck

E.2. Train usage questions

Selecteer 1 antwoord
Hoe vaak reist u met de trein?

- ❍ Nooit
- ❍ Minder dan 1 keer per jaar
- ❍ 1 keer per jaar
- ❍ Een paar keer per jaar
- ❍ 1 keer per maand
- ❍ Een paar keer per maand
- ❍ 1 keer per week
- ❍ Een paar keer per week
- ❍ Elke dag

Selecteer 1 antwoord
Hoeveel retour langeafstand reizen (330+ km) heeft u in het afgelopen jaar gemaakt?

- ❍ Geen
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4 - 6
- ❍ 7 - 9

❍ 10 of meer

Geef een numeriek antwoord
Hoeveel van deze reizen heeft u (deels) gemaakt met de trein?

Selecteer 1 antwoord
Waren de meeste van deze reizen voor een zakelijk of vrijetijds doeleinde?

❍ Zakelijk
❍ Vrije tijd

Selecteer 1 antwoord
Met wie heeft u de meeste van deze langeafstand reizen gemaakt?

❍ Alleen
❍ Met een partner
❍ Met een vriend/met vrienden
❍ Met familie
❍ Met een collega/met collega's
❍ Ik heb niet gereisd over lange afstanden
❍ Anders, namelijk...

E.3. Explanation of the choice context and alternatives

U krijgt hierna 9 reissituaties te zien. In elke situatie ziet u drie reisopties. Het is steeds de bedoeling dat u kiest voor de reis die in het echt ook uw voorkeur zou hebben.

Stel u voor dat u alleen reist voor een vrijetijds doeleinde. U wilt een langeafstand treinreis van ongeveer 700-850 km maken. Deze afstand is vergelijkbaar met de reizen:

- Amsterdam - Munchen (∼800 km)
- Amsterdam - Basel (∼750 km)
- Amsterdam - Lyon (∼850 km)

U krijgt voor de reis steeds drie reisopties te zien. Elke reisoptie wordt gedefinieerd met zes eigenschappen.

1. Reiskosten

Figure E.1: Reiskosten

Hier kunt u de kosten zien voor een enkele reis, 2de klas kaartje. De prijs is steeds 50, 70, 90, of 110 euro.

2. Overstaptijd

Figure E.2: Overstaptijd

Hier kunt u zien wat de overstaptijd is. Dit is de geplande tijd tussen de aankomst van een trein en het vertrek van de volgende. De overstaptijd is steeds 5, 20, 35 of 50 minuten.

3. Reistijd

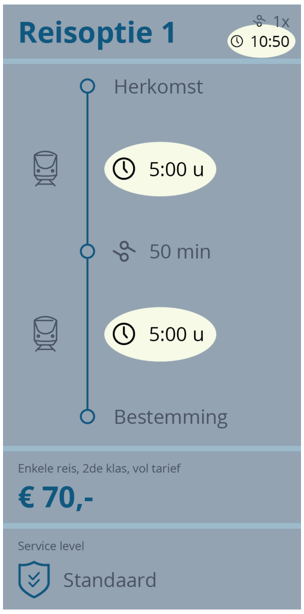


Figure E.3: Reistijd

Hier kunt u zien hoe lang elk deel van de reis duurt. De losse onderdelen tellen steeds op naar 8, 10 of 12 uur. Rechtbovenin ziet u de totale reistijd inclusief overstaptijd.

4. Aantal overstappen

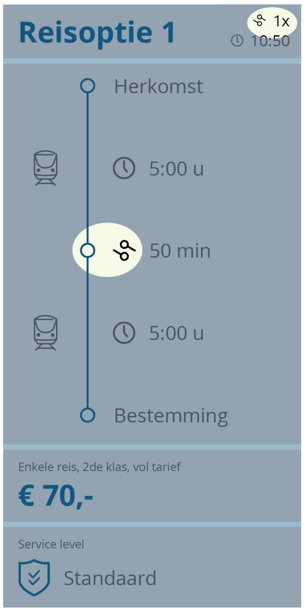


Figure E.4: Aantal overstappen

Een overstap wordt aangegeven met een stip op de lijn en een overstap-icoon. Elke optie heeft 1 of 2 overstappen. Rechtbovenin staat het aantal overstappen aangeven.

5. Verdeling van tijd

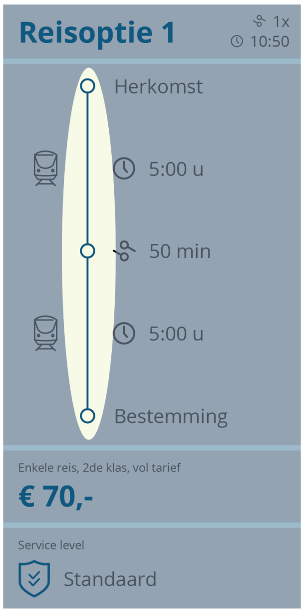


Figure E.5: Verdeling van tijd

Op de lange lijn kunt u zien hoe de tijd en de overstappen zijn verdeeld over de reis. In dit specifieke geval is er één transfer in het midden van de reis. De verdeling is steeds gelijkmatig, ongelijkmatig met de overstap(pen) vroeg in de rit of ongelijkmatig met de overstap(pen) laat in de rit verdeeld.

6. Service level

Figure E.6: Sevice level

Hier kunt u zien wat het service level van de reis is. Deze is Light, Standaard of Premium. Met een Light service ontvangt u een vergoeding wanneer een trein dusdanig verstoord is dat u als vervolg meer dan 30 minuten vertraagd is. U ontvangt alleen vergoeding voor het deel van de verstoorde trein. Met een Standaard service kunt u ook een vergoeding voor de volledige reis ontvangen wanneer een verstoring effect heeft gehad op de hele reis. Met een Premium service reist u met flexibele reistijden, en wordt u in het geval van een verstoring toegewezen aan een zitplaats in een alternatieve trein. Deze informatie is ook weergegeven in onderstaand figuur.

Figure E.7: Service levels

E.4. The choice experiment

Beantwoord voor elke keuzeset binnen het blok de volgende vragen:

[De keuzesets zijn opgedeeld in 4 blokken van elk 9 keuzesets. Deze zijn hieronder in paragraven D.4.1 t/m D.4.4 te zien. Elke respondent krijgt dus maar 1 van de 4 blokken. Het is de bedoeling dat elk blok even vaak wordt ingevuld.]

Selecteer 1 antwoord
U maakt een langeafstand treinreis van ongeveer 700-850 km, dus bijvoorbeeld van Amsterdam naar Basel, Lyon of Munchen. U reist alleen en voor een vrije tijds doeleinde. Welke van de reisopties zou u kiezen?

- ❍ Reisoptie 1
- ❍ Reisoptie 2
- ❍ Reisoptie 3

Selecteer 1 antwoord

Later vindt u een vierde reisoptie. Deze heeft een totale duur van 12 uur, servicelevel 'light' en hij kost 110 euro. Het is echter een rechtstreekse trein (geen overstappen).

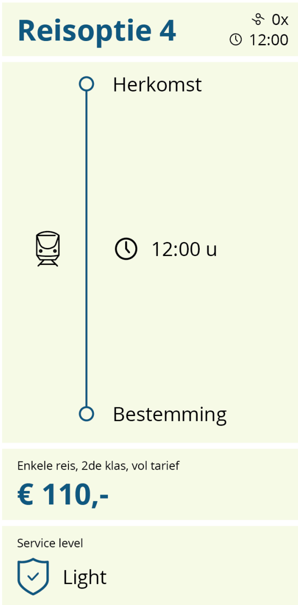


Figure E.8: Reisoptie 4

Zou u bij uw vorige keuze blijven, of kiezen voor deze nieuwe optie?

- ❍ Ik zou kiezen voor reisoptie 4
- ❍ Ik zou bij mijn vorige reiskeuze blijven

Selecteer 1 antwoord
Gegeven deze 4 reisopties, zou u ervoor kiezen om uw langeafstand reis (700-850 km) met de trein te maken? Of zou u voor een ander vervoermiddel kiezen?

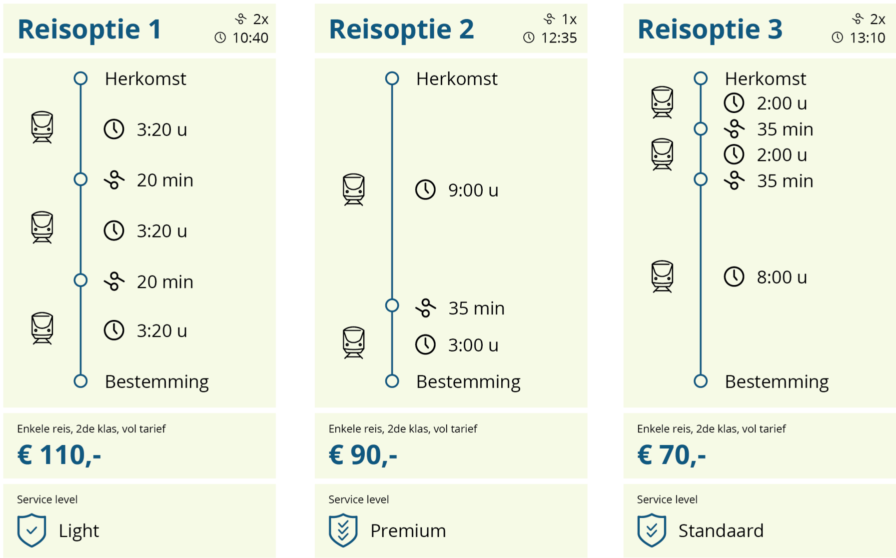
- ❍ Ik zou de reis met de trein maken
- ❍ Ik zou kiezen voor een ander vervoermiddel (bv. Auto, Vliegtuig)

Beantwoord de volgende vraag 1 keer na het keuzeexperiment:

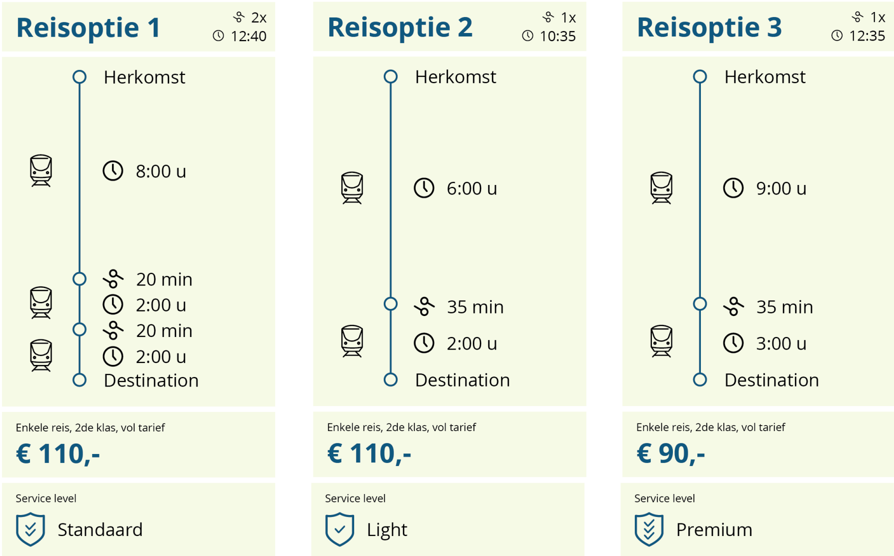
Selecteer 1 antwoord
Wanneer u er niet voor kiest om met de trein te reizen, welk vervoermiddel zou u dan kiezen?

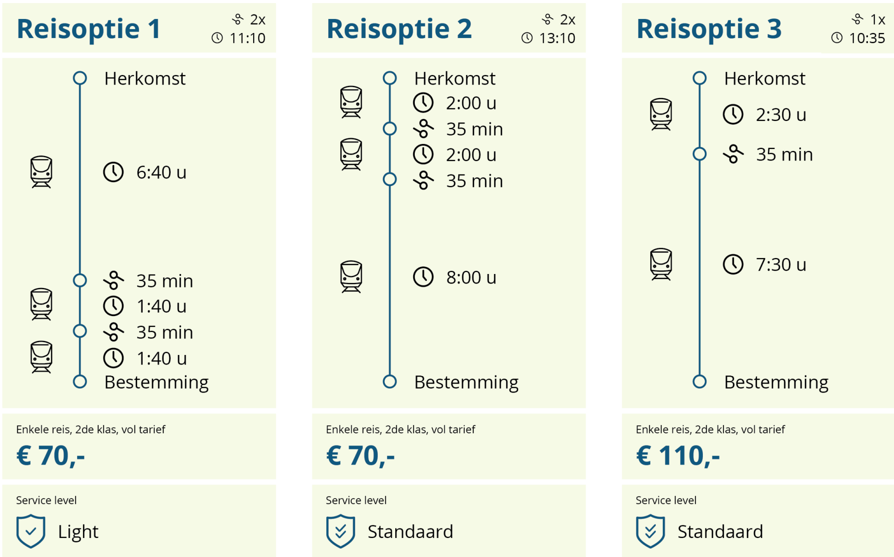
- ❍ Ik kies altijd voor de trein
- ❍ Auto
- ❍ Vliegtuig
- ❍ Anders, namelijk...

E.4.1. Block 1 choice sets

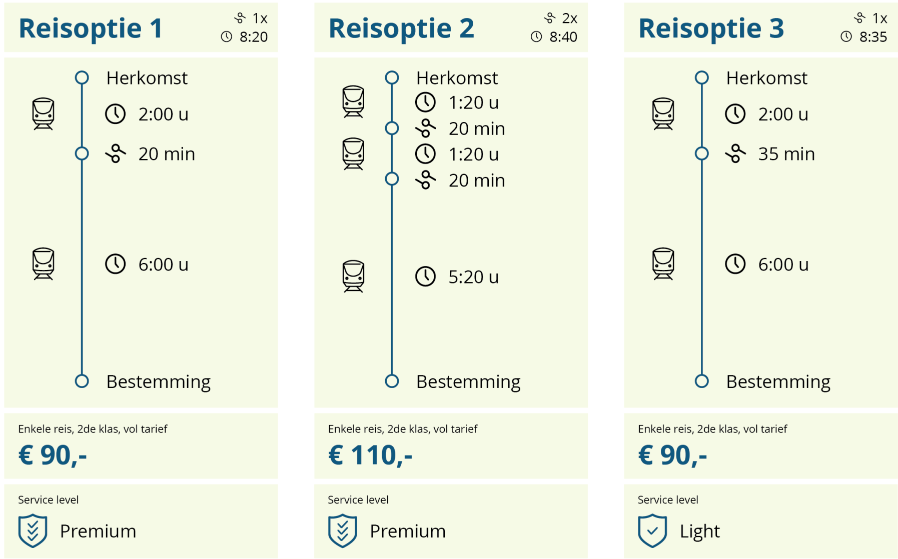



Reisoptie 1
2x
13:40
Herkomst
4:00 u
50 min
4:00 u
50 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Premium
Reisoptie 2
2x
9:40
Herkomst
5:20 u
50 min
1:20 u
50 min
1:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Light
Reisoptie 3
2x
12:10
Herkomst
2:00 u
5 min
2:00 u
5 min
8:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Standaard
Reisoptie 1
1x
8:35
Herkomst
2:00 u
35 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Light
Reisoptie 2
2x
11:10
Herkomst
6:40 u
35 min
1:40 u
35 min
1:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light
Reisoptie 3
1x
12:20
Herkomst
3:00 u
20 min
9:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light
Reisoptie 1
2x
8:10
Herkomst
2:40 u
5 min
2:40 u
5 min
2:40 u
Destination
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Premium
Reisoptie 2
1x
12:35
Herkomst
6:00 u
35 min
6:00 u
Destination
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Premium
Reisoptie 3
1x
10:35
Herkomst
5:00 u
35 min
5:00 u
Destination
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Standaard


Reisoptie 1
2x
12:40
Herkomst
8:00 u
20 min
2:00 u
20 min
2:00 u
Destination
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Standaard
Reisoptie 2
1x
10:35
Herkomst
6:00 u
35 min
2:00 u
Destination
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Light
Reisoptie 3
1x
12:35
Herkomst
9:00 u
35 min
3:00 u
Destination
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Premium


Reisoptie 1
2x
11:10
Herkomst
6:40 u
35 min
1:40 u
35 min
1:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light
Reisoptie 2
2x
13:10
Herkomst
2:00 u
35 min
2:00 u
35 min
8:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Standaard
Reisoptie 3
1x
10:35
Herkomst
2:30 u
35 min
7:30 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Standaard


Reisoptie 1
1x
8:20
Herkomst
4:00 u
20 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Standaard
Reisoptie 2
1x
10:35
Herkomst
2:30 u
35 min
7:30 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Standaard
Reisoptie 3
1x
8:35
Herkomst
6:00 u
35 min
2:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Light



E.4.2. Block 2 choice sets

Reisoptie 1 — 1x — 12:05

Herkomst
3:00 u
5 min
9:00 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 50,-

Service level
Light

Reisoptie 2 — 1x — 10:35

Herkomst
5:00 u
35 min
5:00 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 90,-

Service level
Standaard

Reisoptie 3 — 2x — 11:40

Herkomst
1:40 u
50 min
1:40 u
50 min
6:40 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 50,-

Service level
Standaard

Reisoptie 1 — 1x — 12:20

Herkomst
3:00 u
20 min
9:00 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 70,-

Service level
Light

Reisoptie 2 — 1x — 12:50

Herkomst
9:00 u
50 min
3:00 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 70,-

Service level
Premium

Reisoptie 3 — 1x — 8:05

Herkomst
4:00 u
5 min
4:00 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 50,-

Service level
Standaard

Reisoptie 1 — 1x — 12:20

Herkomst
9:00 u
20 min
3:00 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 90,-

Service level
Standaard

Reisoptie 2 — 2x — 9:40

Herkomst
5:20 u
50 min
1:20 u
50 min
1:20 u
Bestemming

Enkele reis, 2de klas, vol tarief
€ 90,-

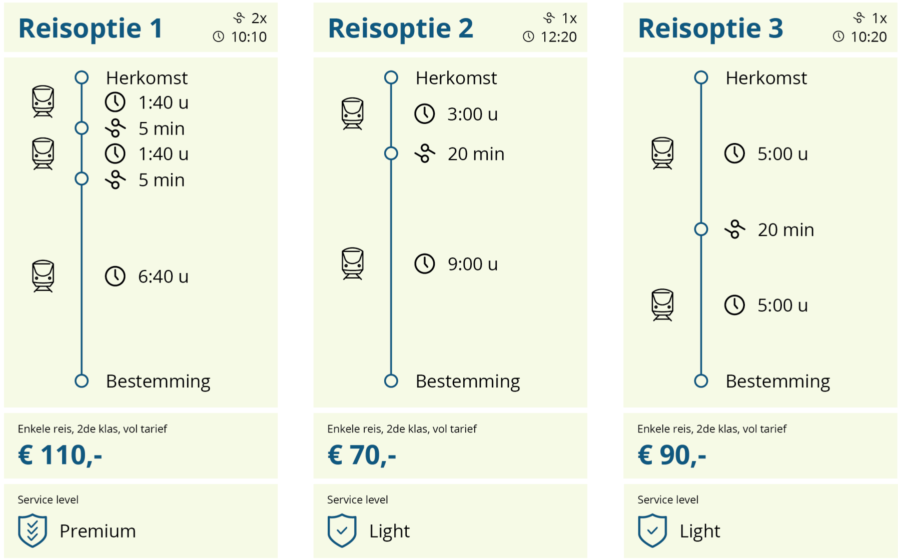
Service level
Standaard

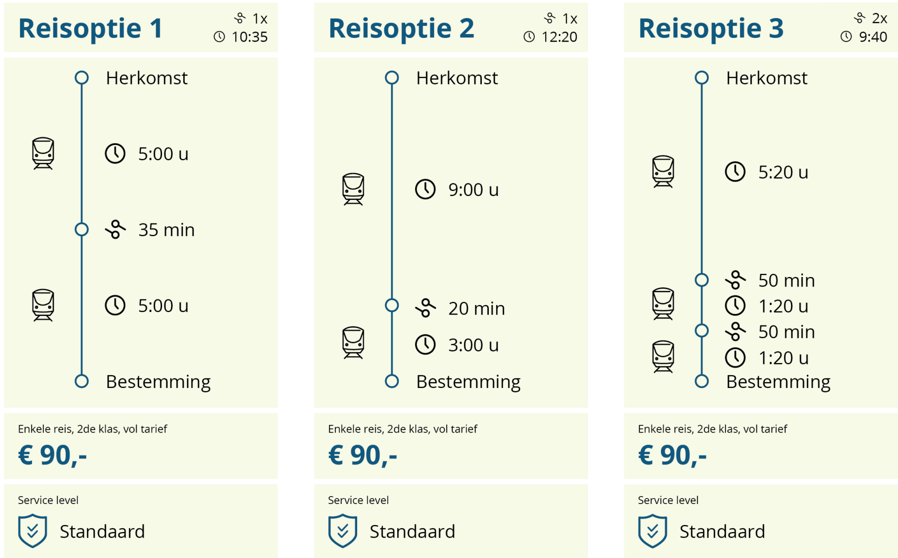
Reisoptie 3 — 1x — 10:20

Herkomst
7:30 u
20 min
2:30 u
Bestemming

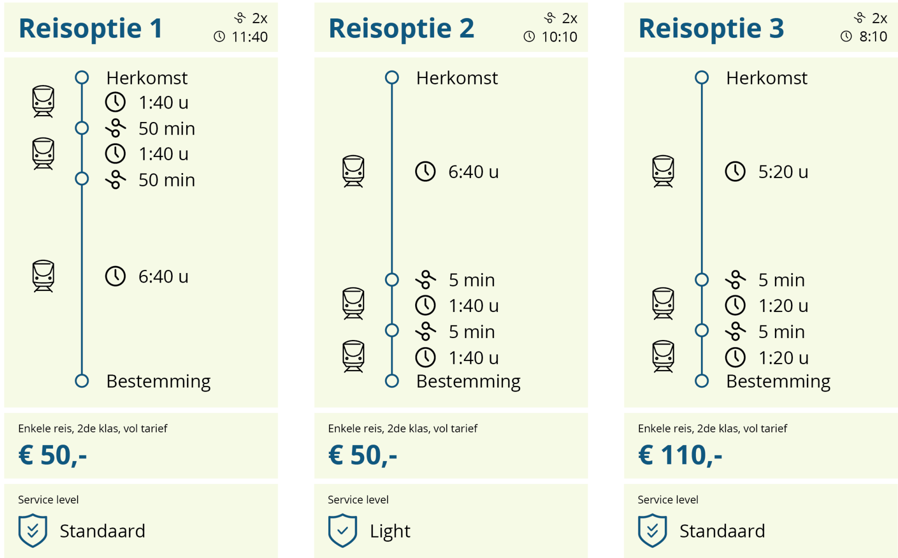
Enkele reis, 2de klas, vol tarief
€ 70,-

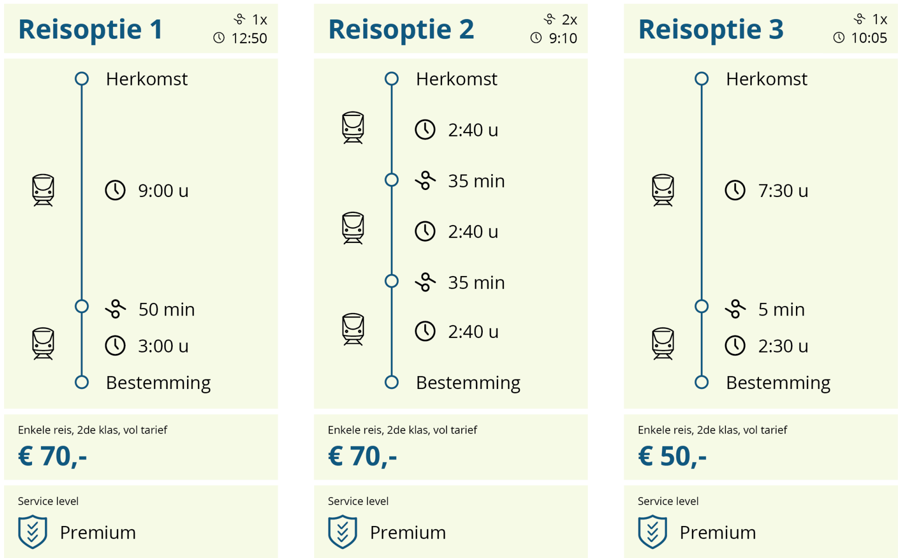
Service level
Premium


Reisoptie 1
2x
10:10
Herkomst
1:40 u
5 min
1:40 u
5 min
6:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Premium
Reisoptie 2
1x
12:20
Herkomst
3:00 u
20 min
9:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light
Reisoptie 3
1x
10:20
Herkomst
5:00 u
20 min
5:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Light

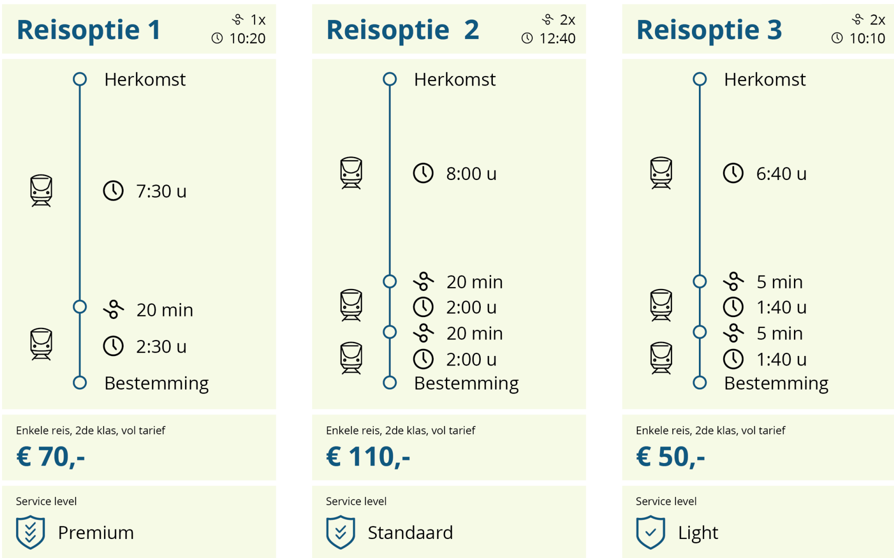

Reisoptie 1
1x
10:35
Herkomst
5:00 u
35 min
5:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Standaard
Reisoptie 2
1x
12:20
Herkomst
9:00 u
20 min
3:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Standaard
Reisoptie 3
2x
9:40
Herkomst
5:20 u
50 min
1:20 u
50 min
1:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Standaard

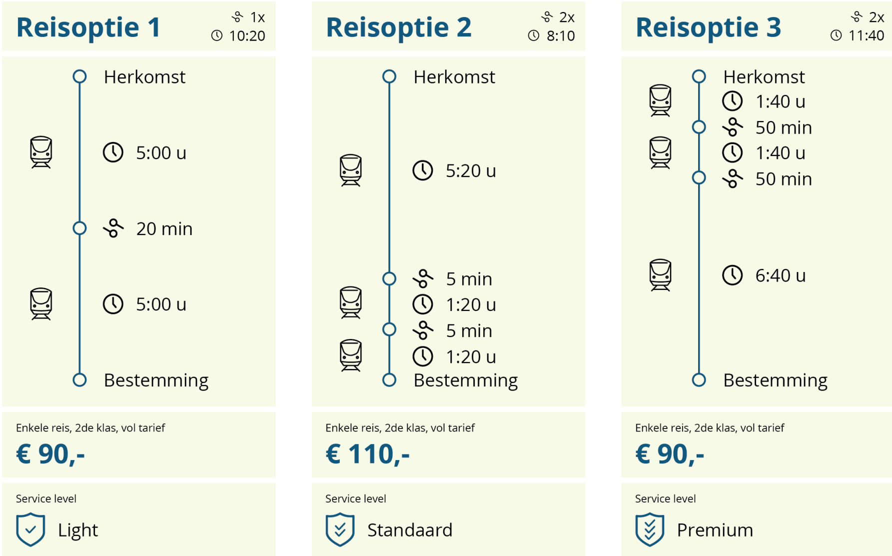

Reisoptie 1
2x
13:40
Herkomst
4:00 u
50 min
4:00 u
50 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Light
Reisoptie 2
2x
10:40
Herkomst
3:20 u
20 min
3:20 u
20 min
3:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Light
Reisoptie 3
1x
12:35
Herkomst
6:00 u
35 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Premium

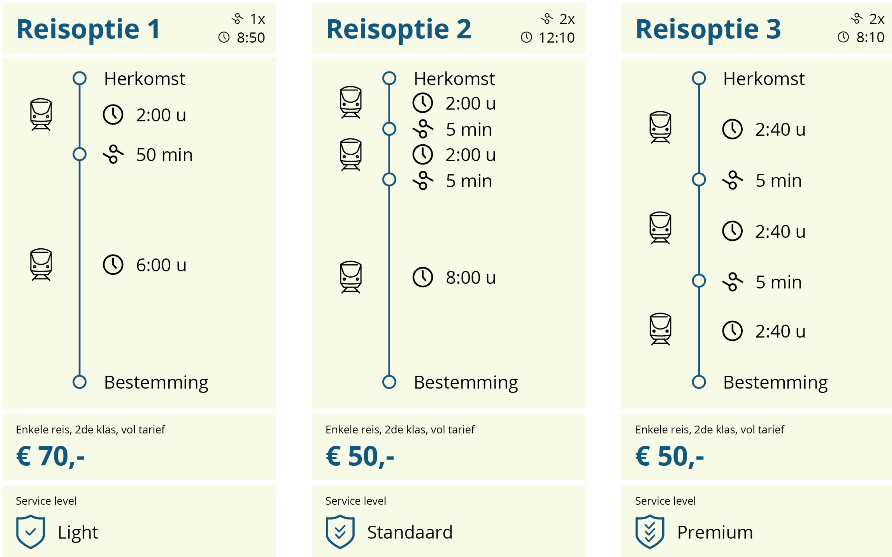

Reisoptie 1
2x
11:40
Herkomst
1:40 u
50 min
1:40 u
50 min
6:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Standaard
Reisoptie 2
2x
10:10
Herkomst
6:40 u
5 min
1:40 u
5 min
1:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Light
Reisoptie 3
2x
8:10
Herkomst
5:20 u
5 min
1:20 u
5 min
1:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Standaard

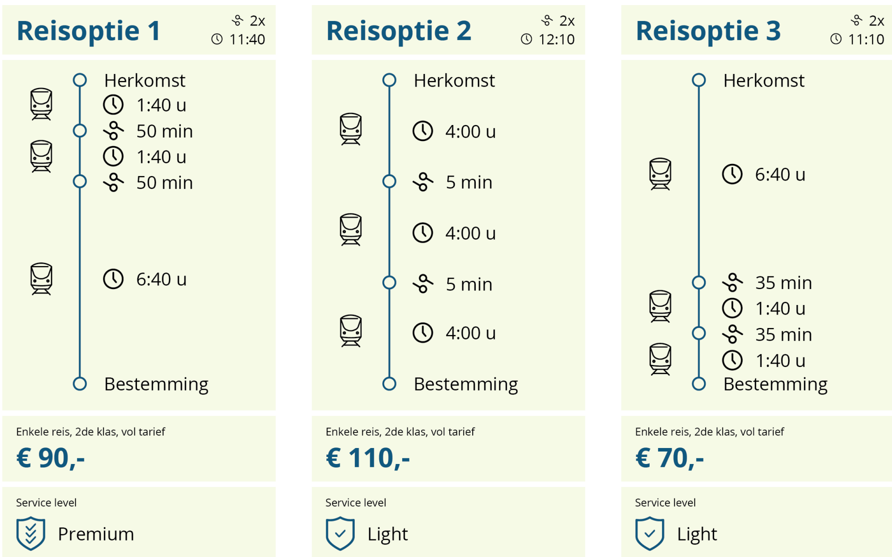

Reisoptie 1
1x
12:50
Herkomst
9:00 u
50 min
3:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Premium
Reisoptie 2
2x
9:10
Herkomst
2:40 u
35 min
2:40 u
35 min
2:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Premium
Reisoptie 3
1x
10:05
Herkomst
7:30 u
5 min
2:30 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Premium

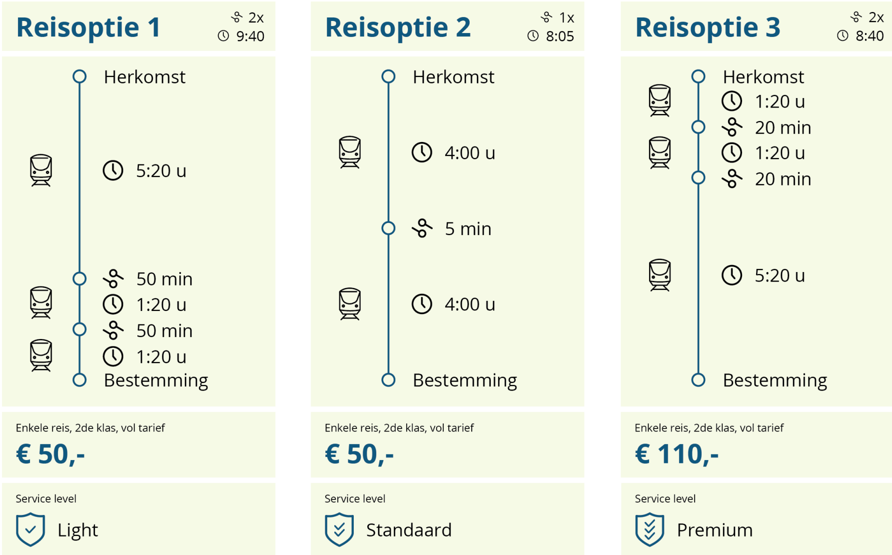
E.4.3. Block 3 choice sets

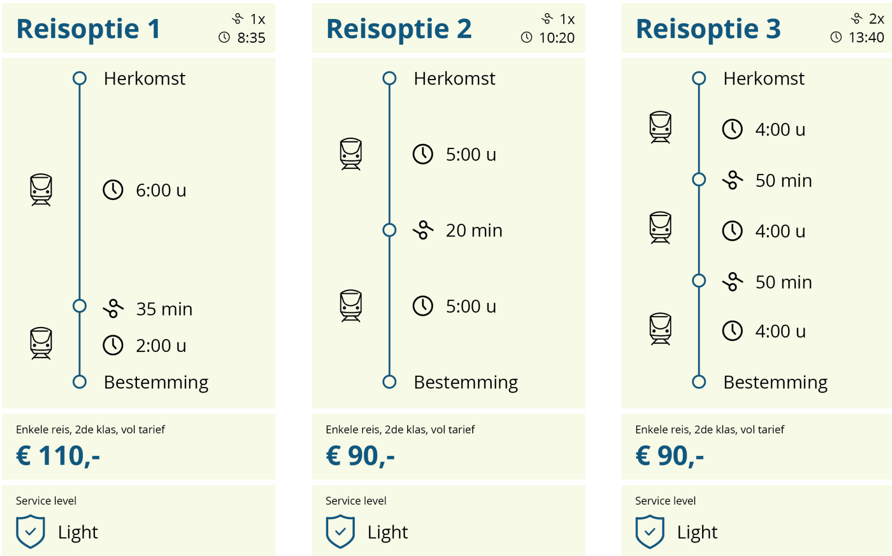


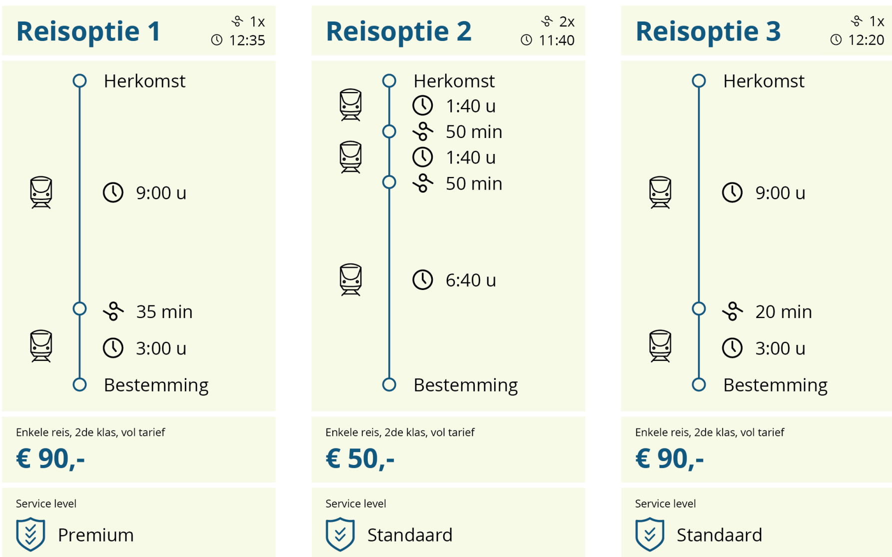

Reisoptie 1
1x
10:20
Herkomst
5:00 u
20 min
5:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Light
Reisoptie 2
2x
8:10
Herkomst
5:20 u
5 min
1:20 u
5 min
1:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Standaard
Reisoptie 3
2x
11:40
Herkomst
1:40 u
50 min
1:40 u
50 min
6:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Premium

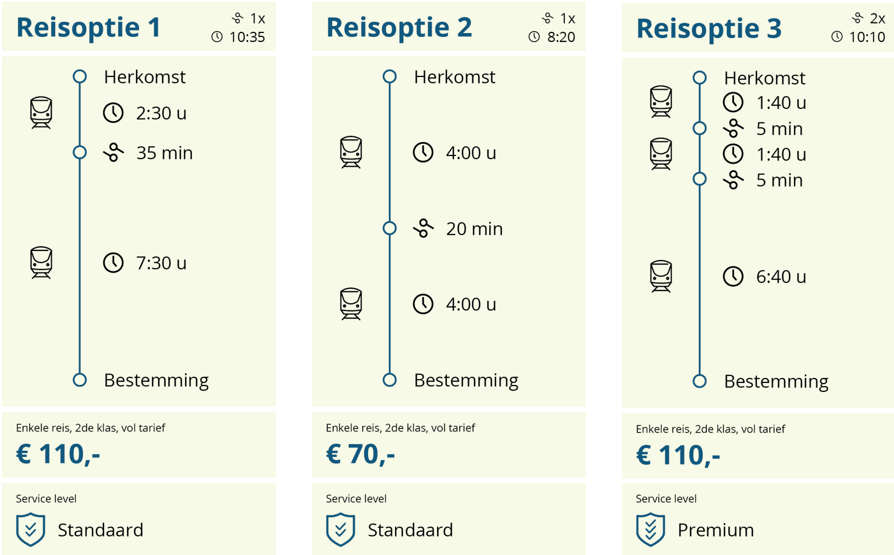

Reisoptie 1
1x
8:50
Herkomst
2:00 u
50 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light
Reisoptie 2
2x
12:10
Herkomst
2:00 u
5 min
2:00 u
5 min
8:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Standaard
Reisoptie 3
2x
8:10
Herkomst
2:40 u
5 min
2:40 u
5 min
2:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Premium


Reisoptie 1
2x
11:40
Herkomst
1:40 u
50 min
1:40 u
50 min
6:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Premium
Reisoptie 2
2x
12:10
Herkomst
4:00 u
5 min
4:00 u
5 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Light
Reisoptie 3
2x
11:10
Herkomst
6:40 u
35 min
1:40 u
35 min
1:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light

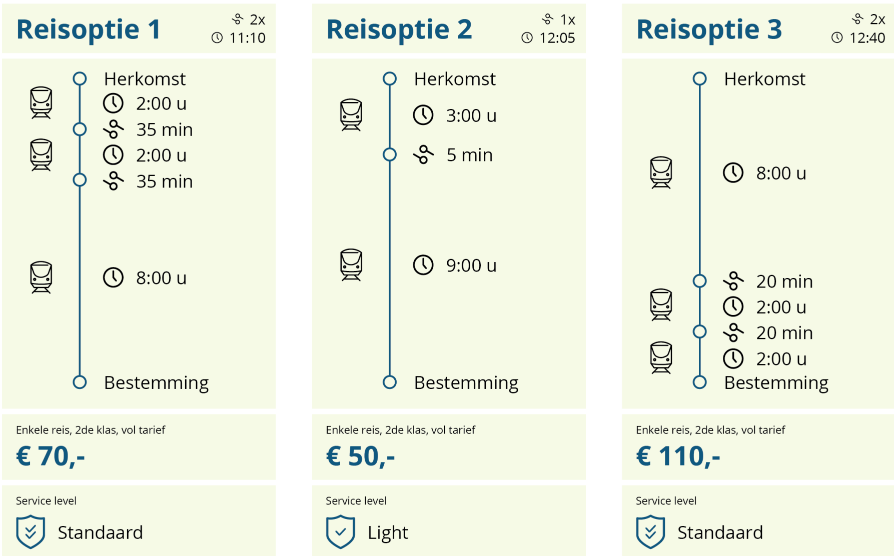

Reisoptie 1
2x
9:40
Herkomst
5:20 u
50 min
1:20 u
50 min
1:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Light
Reisoptie 2
1x
8:05
Herkomst
4:00 u
5 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Standaard
Reisoptie 3
2x
8:40
Herkomst
1:20 u
20 min
1:20 u
20 min
5:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Premium


Reisoptie 1
1x
8:35
Herkomst
6:00 u
35 min
2:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Light
Reisoptie 2
1x
10:20
Herkomst
5:00 u
20 min
5:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Light
Reisoptie 3
2x
13:40
Herkomst
4:00 u
50 min
4:00 u
50 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Light

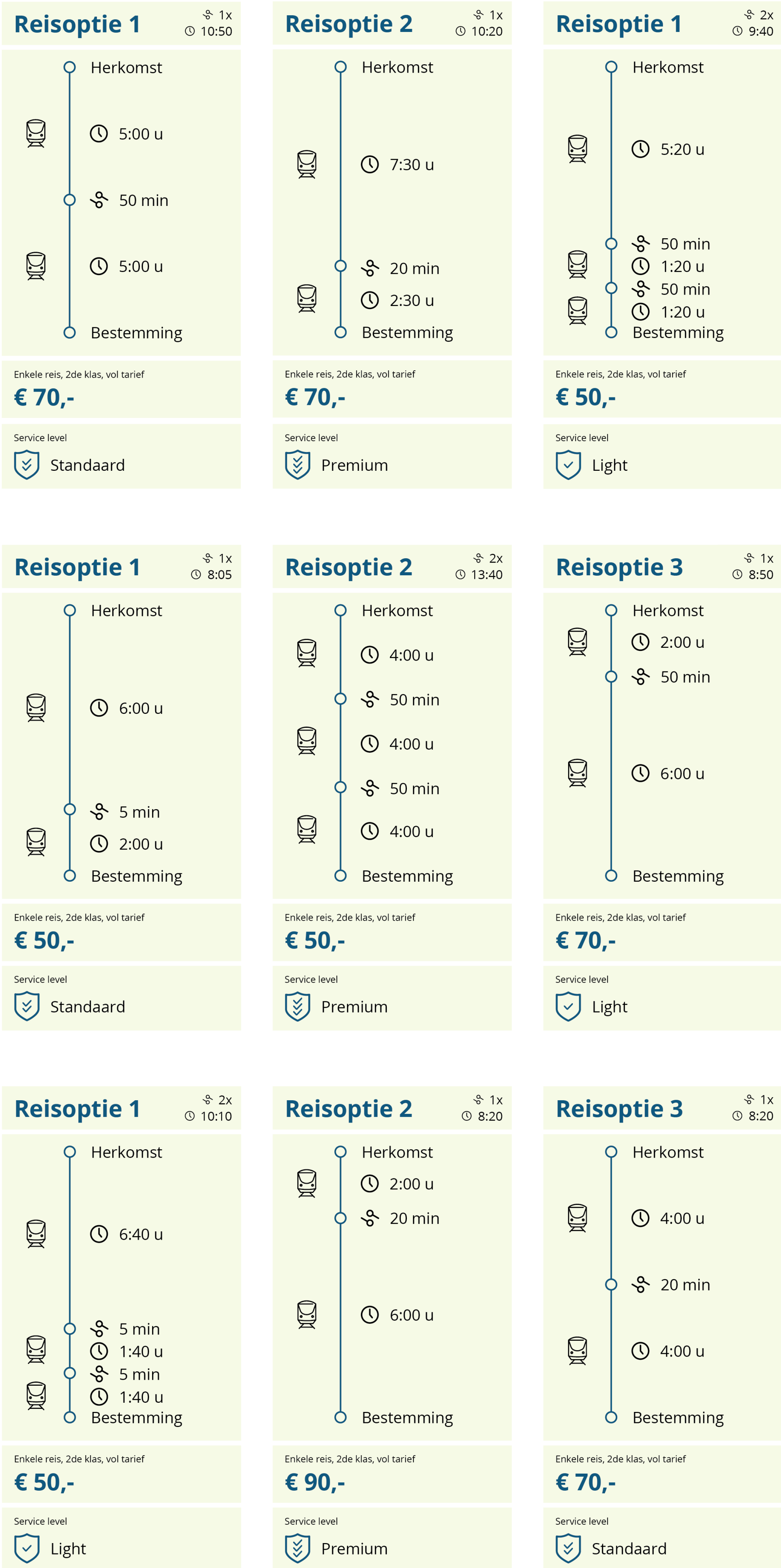

Reisoptie 1
1x
12:35
Herkomst
9:00 u
35 min
3:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Premium
Reisoptie 2
2x
11:40
Herkomst
1:40 u
50 min
1:40 u
50 min
6:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Standaard
Reisoptie 3
1x
12:20
Herkomst
9:00 u
20 min
3:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Standaard

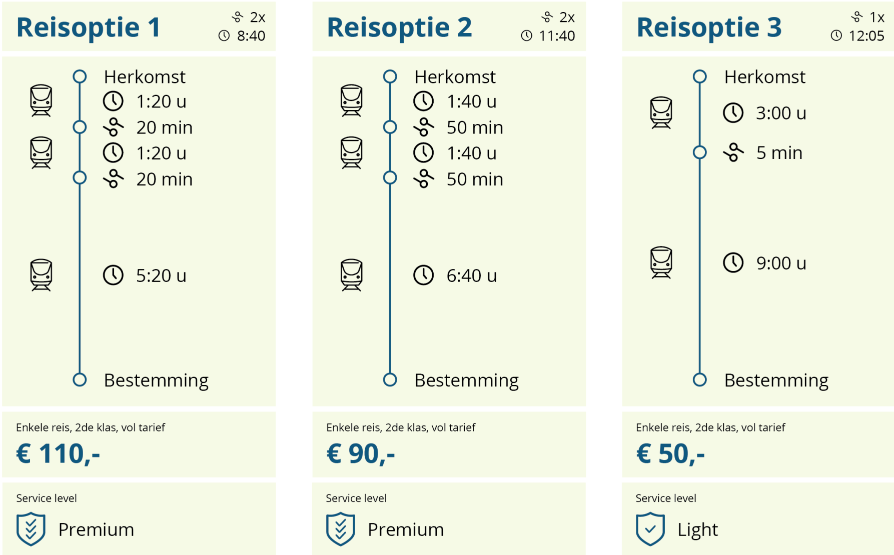


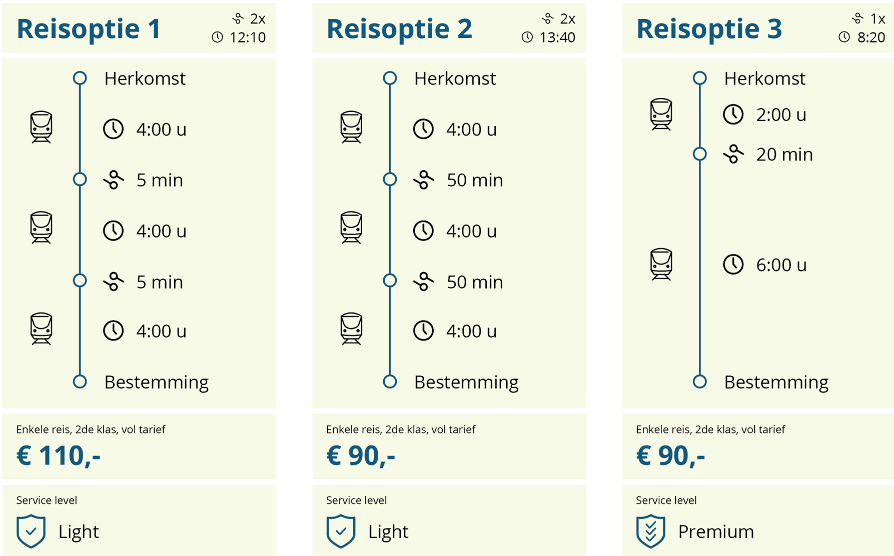
E.4.4. Block 4 choice sets




Reisoptie 1
2x
9:40
Herkomst
5:20 u
50 min
1:20 u
50 min
1:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Standaard
Reisoptie 2
1x
8:50
Herkomst
2:00 u
50 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light
Reisoptie 3
2x
10:40
Herkomst
3:20 u
20 min
3:20 u
20 min
3:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Light
Reisoptie 1
1x
12:35
Herkomst
6:00 u
35 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 110,-
Service level
Premium
Reisoptie 2
1x
8:35
Herkomst
2:00 u
35 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Light
Reisoptie 3
1x
12:50
Herkomst
9:00 u
50 min
3:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Premium
Reisoptie 1
2x
9:10
Herkomst
2:40 u
35 min
2:40 u
35 min
2:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Premium
Reisoptie 2
2x
10:10
Herkomst
1:40 u
5 min
1:40 u
5 min
6:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 100,-
Service level
Premium
Reisoptie 3
1x
10:50
Herkomst
5:00 u
50 min
5:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Standaard


Reisoptie 1
1x
10:50
Herkomst
5:00 u
50 min
5:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Standaard
Reisoptie 2
1x
10:20
Herkomst
7:30 u
20 min
2:30 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Premium
Reisoptie 1
2x
9:40
Herkomst
5:20 u
50 min
1:20 u
50 min
1:20 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Light
Reisoptie 1
1x
8:05
Herkomst
6:00 u
5 min
2:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Standaard
Reisoptie 2
2x
13:40
Herkomst
4:00 u
50 min
4:00 u
50 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Premium
Reisoptie 3
1x
8:50
Herkomst
2:00 u
50 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Light
Reisoptie 1
2x
10:10
Herkomst
6:40 u
5 min
1:40 u
5 min
1:40 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 50,-
Service level
Light
Reisoptie 2
1x
8:20
Herkomst
2:00 u
20 min
6:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 90,-
Service level
Premium
Reisoptie 3
1x
8:20
Herkomst
4:00 u
20 min
4:00 u
Bestemming
Enkele reis, 2de klas, vol tarief
€ 70,-
Service level
Standaard





E.5. Factor statements

Selecteer 1 antwoord

De volgende stellingen gaan over uw intentie om milieuvriendelijke vervoermiddelen te gebruiken. Geef van elke van onderstaande stellingen aan hoe zeer u het er mee eens bent.

- ❍ Helemaal mee oneens
- ❍ Mee oneens
- ❍ Neutraal
- ❍ Mee eens
- ❍ Helemaal mee eens

1. Ik vind het belangrijk om milieuvriendelijke vervoermiddelen te gebruiken, zoals de fiets of het openbaar vervoer.
2. Ik gebruik milieuvriendelijke transportmiddelen, zelfs als dat betekent dat ik een minder comfortabele of gemakkelijke reis moet maken.
3. Ik geloof dat individuele acties, zoals het kiezen van milieuvriendelijk transport, een verschil kunnen maken in de aanpak van klimaatverandering.

4. Ik zoek actief naar milieuvriendelijke transportopties in mijn dagelijks leven.

Selecteer 1 antwoord
De volgende stellingen gaan over uw persoonlijke voorkeur voor treinreizen. Geef van elke van onderstaande stellingen aan hoe zeer u het er mee eens bent.

❍ Helemaal mee oneens
❍ Mee oneens
❍ Neutraal
❍ Mee eens
❍ Helemaal mee eens

1. Ik vind treinreizen ontspannend en plezierig.
2. Ik voel een sterke affiniteit met treinen en ervaringen gerelateerd aan treinen.
3. Ik geniet van het uitzicht en de landschappen die treinreizen bieden.
4. Ik voel een gevoel van opwinding of avontuur wanneer ik aan een treinreis begin.

Selecteer 1 antwoord
De volgende stellingen gaan over uw (slechte) ervaringen met treinreizen. Geef van elke van onderstaande stellingen aan hoe zeer u het er mee eens bent.

❍ Helemaal mee oneens
❍ Mee oneens
❍ Neutraal
❍ Mee eens
❍ Helemaal mee eens

1. Ik heb wel eens een slechte ervaring gehad met een langeafstand treinreis.
2. Ik heb in het algemeen vaak slechte ervaringen met reizen per trein.
3. Als ik een slechte ervaring met treinreizen over lange afstand heb gehad, is het niet waarschijnlijk dat ik de volgende keer weer voor de trein zal kiezen.
4. Ik verwacht dat er een verstoring zal zijn als ik ervoor kies om met de trein te reizen over lange aftanden.

E.6. Socio-demographics

Selecteer steeds 1 antwoord

Wat is uw geslacht?

❍ Vrouw
❍ Man
❍ Anders (bijvoorveeld: Non-binair)

Wat is uw geboortjaar? (Geef hier een dropdown menu van geboortejaren 1924 tot en met 2024)

Wat is uw hoogst genoten opleiding?

❍ Geen opleiding
❍ Basisschool
❍ Middelbare school
❍ MBO 1 of 2
❍ MBO 3 of 4
❍ HBO Bachelor
❍ HBO Master
❍ Post-HBO opleiding
❍ WO Bachelor
❍ WO Master
❍ Doctoraat of post-doctoraat

Wat is uw huidige arbeidsstatus?

- ❍ Voltijd werkzaam
- ❍ Deeltijd werkzaam
- ❍ Werkloos/werkzoekend
- ❍ Student
- ❍ Gepensioneerd
- ❍ Arbeidsongeschikt

Wat is uw bruto jaarlijkse inkomen?

- ❍ 0 - 10.000 euro
- ❍ 10.000 - 19.999 euro
- ❍ 20.000 - 29.999 euro
- ❍ 30.000 - 39.999 euro
- ❍ 40.000 - 49.999 euro
- ❍ 50.000 - 59.999 euro
- ❍ 60.000 - 69.999 euro
- ❍ 70.000 - 79.999 euro
- ❍ 80.000 - 89.999 euro
- ❍ 90.000 - 99.999 euro
- ❍ 100.000 - 199.999 euro
- ❍ 200.000 euro of meer
- ❍ Zeg ik liever niet

In welke provincie woont u?

- ❍ Drenthe
- ❍ Flevoland
- ❍ Fryslân
- ❍ Gelderland
- ❍ Groningen
- ❍ Limburg
- ❍ Noord-Brabant
- ❍ Noord-Holland
- ❍ Overijssel
- ❍ Zuid-Holland
- ❍ Zeeland
- ❍ Ik woon niet in Nederland

Hoeveel auto's (of motorfietsen of gelijkaardige gemotoriseerde voertuigen zonder snelheidsbeperking) heeft u dagelijks tot uw beschikking?

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3 of meer

E.7. Word of gratitude

Hartelijk dank voor het invullen van deze enquête. Als u geïnteresseerd bent in de resultaten van dit onderzoek, kun u het rapport vanaf eind augustus vinden op de Repository van de TU Delft. Als u nog vragen of opmerkingen heeft, kunt u deze hier achterlaten.

Ruimte voor opmerkingen

F

Survey webversion

NS Panel

0%

Welkom!

Deze vragenlijst gaat over het maken van langeafstandsreizen. Hiermee bedoelen we reizen naar het buitenland, over een afstand van meer dan 300 kilometer. Deze reizen kun je bijvoorbeeld maken met de auto, de trein of het vliegtuig.

Hoe vaak heb je in het afgelopen jaar een dergelijke reis gemaakt?

Let op: een retour geldt als één reis.

- ○ Geen enkele keer
- ○ 1 keer
- ○ 2 keer
- ○ 3 keer
- ○ 4 tot 6 keer
- ○ 7 tot 9 keer
- ○ 10 keer of meer

NS Panel

2%

En hoeveel van deze reizen heb je (deels) gemaakt met de trein?

Let op: een retour geldt als één reis.

- Geen enkele reis
- 1 reis
- 2 reizen
- 3 reizen
- 4 tot 6 reizen
- 7 tot 9 reizen
- 10 reizen of meer

NS Panel

5%

Waren de meeste van deze reizen voor zakelijke doeleinden of voor vrijetijds doeleinden?

- Zakelijk
- Vrije tijd

NS Panel

7%

Met wie heb je de meeste van deze reizen gemaakt?

- ◯ Alleen
- ◯ Met mijn partner
- ◯ Met een vriend/met vrienden
- ◯ Met familie
- ◯ Met een collega/met collega's
- ◯ Anders, namelijk:

NS Panel

10%

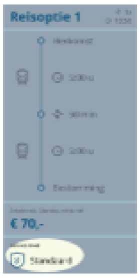
Stel je gaat een internationale treinreis maken, over een afstand van zo'n 700-850 kilometer. Voorbeelden van zo'n reis kunnen zijn:

- Van Amsterdam naar München (circa 800 kilometer)
- Van Amsterdam naar Basel (circa 750 kilometer)
- Van Amsterdam naar Lyon (circa 850 kilometer)

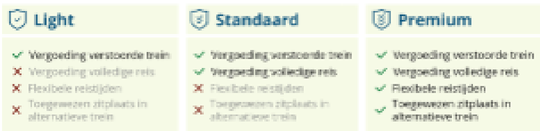
Je krijgt straks 9 keer een keuze voorgelegd tussen verschillende reisopties. We zijn benieuwd voor welke reisoptie je in elke situatie zou kiezen.

De reisopties verschillen telkens op de volgende kenmerken:

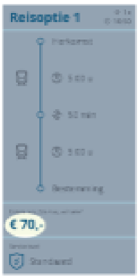
1. Service level: er zijn drie service levels: 'Light', 'Standaard' en 'Premium'.



Bij een vertraging van meer dan 30 minuten ontvang je een vergoeding. Bij het service level 'Light' wordt alleen het vertraagde deel van de reis vergoed. Bij 'Standaard' en 'Premium' wordt de gehele reis vergoed. Bij het service level 'Premium' reis je daarnaast met flexibele reistijden en krijg je in het geval van een verstoring een zitplaats in een alternatieve trein toegewezen. Zie ook onderstaande afbeelding voor de verschillen tussen de service levels.

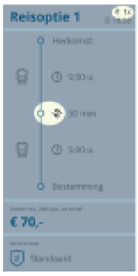


2. Reiskosten: dit betreft de kosten voor een enkele reis, op basis van een 2e klas kaartje.

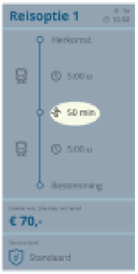


3. Aantal overstappen: een overstap wordt aangegeven met een stip op de lijn en een overstap-icoon. Rechtsboven vind je het totaal aantal overstappen.

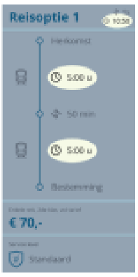
3. Aantal overstappen: een overstap wordt aangegeven met een stip op de lijn en een overstap-icoon. Rechtsboven vind je het totaal aantal overstappen.



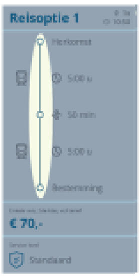
4. Overstaptijd: de geplande tijd tussen de aankomst van een trein en het vertrek van de volgende.



5. Reistijd: hier zie je hoe lang elk deel van de reis duurt. Rechtsboven vind je de totale reistijd, inclusief de overstaptijd.



6. Verdeling van tijd: op de lange lijn zie je hoe de reistijd en de overstappen zijn verdeeld over de reis. In onderstaande voorbeeld is er één overstap in het midden van de reis.



Klik nu op 'Volgende' om naar de keuzescenario's te gaan.

NS Panel

12%

Stel je maakt een internationale treinreis, met een afstand van ongeveer 700-850 kilometer, dus bijvoorbeeld van Amsterdam naar Basel, Lyon of Munchen. Je reist alleen en voor vrijetijds doeleinden.

Stel je kunt kiezen uit onderstaande reisopties. Welke optie zou je kiezen?

Reisoptie 1 (1x, 10:05)
- Herkomst
- 7:30 u
- 5 min
- 2:30 u
- Bestemming

Enkele reis, 2de klas, vol tarief
€ 50,-

Service level
Premium

Reisoptie 2 (2x, 8:10)
- Herkomst
- 2:40 u
- 5 min
- 2:40 u
- 5 min
- 2:40 u
- Bestemming

Enkele reis, 2de klas, vol tarief
€ 50,-

Service level
Premium

Reisoptie 3 (2x, 13:40)
- Herkomst
- 4:00 u
- 50 min
- 4:00 u
- 50 min
- 4:00 u
- Bestemming

Enkele reis, 2de klas, vol tarief
€ 50,-

Service level
Premium

NS Panel

15%

Stel je vindt later nog een vierde reisoptie. Welke optie zou je nu kiezen?

Reisoptie 2 (2x, 8:10)
- Herkomst
- 2:40 u
- 5 min
- 2:40 u
- 5 min
- 2:40 u
- Bestemming

Enkele reis, 2de klas, vol tarief
€ 50,-

Service level
Premium

Reisoptie 4 (0x, 12:00)
- Herkomst
- 12:00 u
- Bestemming

Enkele reis, 2de klas, vol tarief
€ 110,-

Service level
Light

NS Panel

18%

Gegeven deze reisoptie, zou je ervoor kiezen om deze reis met de trein te maken? Of zou je voor een ander vervoermiddel kiezen?

- ◯ Ik zou de reis met de trein maken
- ◯ Ik zou kiezen voor een ander vervoermiddel (bijv. auto of vliegtuig)

NS Panel

80%

Wanneer je ervoor kiest om niet met de trein te reizen, welk vervoermiddel zou je dan kiezen?

- ◯ Ik kies altijd voor de trein
- ◯ Auto
- ◯ Vliegtuig
- ◯ Anders, namelijk:

NS Panel

82%

De volgende stellingen gaan over je intentie om milieuvriendelijke vervoermiddelen te gebruiken. Geef van elke van de onderstaande stellingen aan in hoeverre je het hier mee eens of oneens bent.

	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
Ik gebruik milieuvriendelijke transportmiddelen, zelfs als dat betekent dat ik een minder comfortabele of gemakkelijke reis moet maken	○	○	○	○	○
Ik geloof dat individuele acties, zoals het kiezen van milieuvriendelijk transport, een verschil kunnen maken in de aanpak van klimaatverandering	○	○	○	○	○
Ik vind het belangrijk om milieuvriendelijke vervoermiddelen te gebruiken, zoals de fiets of het openbaar vervoer	○	○	○	○	○
Ik zoek actief naar milieuvriendelijke transportopties in mijn dagelijks leven	○	○	○	○	○

NS Panel

85%

De volgende stellingen gaan over je persoonlijke voorkeur voor treinreizen. Geef van elke van onderstaande stellingen aan in hoeverre je het hier mee eens of oneens bent.

	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
Ik voel een sterke affiniteit met treinen en ervaringen gerelateerd aan treinen	○	○	○	○	○
Ik geniet van het uitzicht en de landschappen die treinreizen bieden	○	○	○	○	○
Ik vind treinreizen ontspannend en plezierig	○	○	○	○	○
Ik voel een gevoel van opwinding of avontuur wanneer ik aan een treinreis begin	○	○	○	○	○

NS Panel

88%

De volgende stellingen gaan over (slechte) ervaringen met treinreizen. Geef van elke van de onderstaande stellingen aan in hoeverre je het hier mee eens of oneens bent.

	Helemaal mee oneens	Mee oneens	Neutraal	Mee eens	Helemaal mee eens
Ik heb wel eens een slechte ervaring gehad met een langeafstand treinreis	○	○	○	○	○
Ik heb in het algemeen vaak slechte ervaringen met reizen per trein	○	○	○	○	○
Ik verwacht dat er een verstoring zal zijn als ik ervoor kies om met de trein te reizen over lange aftanden	○	○	○	○	○
Als ik een slechte ervaring met treinreizen over lange afstand heb gehad, is het niet waarschijnlijk dat ik de volgende keer weer voor de trein zal kiezen	○	○	○	○	○

NS Panel

90%

Als laatste volgen nog enkele achtergrondvragen.

In welke provincie woon je?

- ○ Drenthe
- ○ Flevoland
- ○ Fryslân
- ○ Gelderland
- ○ Groningen
- ○ Limburg
- ○ Noord-Brabant
- ○ Noord-Holland
- ○ Overijssel
- ○ Utrecht
- ○ Zuid-Holland
- ○ Zeeland
- ○ Ik woon niet in Nederland

NS Panel

92%

Wat is je bruto jaarlijkse inkomen?

- 0 - 10.000 euro
- 10.000 - 19.999 euro
- 20.000 - 29.999 euro
- 30.000 - 39.999 euro
- 40.000 - 49.999 euro
- 50.000 - 59.999 euro
- 60.000 - 69.999 euro
- 70.000 - 79.999 euro
- 80.000 - 89.999 euro
- 90.000 - 99.999 euro
- 100.000 - 199.999 euro
- 200.000 euro of meer
- Zeg ik liever niet

NS Panel

95%

Hoeveel auto's (of motorfietsen of gelijkaardige gemotoriseerde voertuigen zonder snelheidsbeperking) heb je dagelijks tot je beschikking?

- 0
- 1
- 2
- 3 of meer

NS Panel

98%

Dit waren al onze vragen. Heb je zelf nog vragen of opmerkingen over dit onderzoek?

◯ Ja, namelijk:

◯ Nee, geen opmerkingen

G
Factor analysis - reliability

The reliability of each factor was tested in SPSS by looking at Cronbach's Alpha. Cronbach's Alpha is a measure of internal consistency that can be used to assess the reliability of a set of items. It is based on the number of items and the covariance and variance between item pairs. In table G.1, the value of Cronbach's Alpha is shown for each factor, as well as the value of Cronbach's Alpha when an item is deleted.

Table G.1: Reliability measures

Environmental considerations	
Item	Cronbach's Alpha if item deleted
No	**0,866**
environment1	0,814
environment2	0,816
environment3	0,871
environment4	0,808

Bad experience with (long-distance) train travel	
Item	Cronbach's Alpha if item deleted
No	**0,623**
experience1	0,611
experience2	0,477
experience3	0,621
experience4	0,494

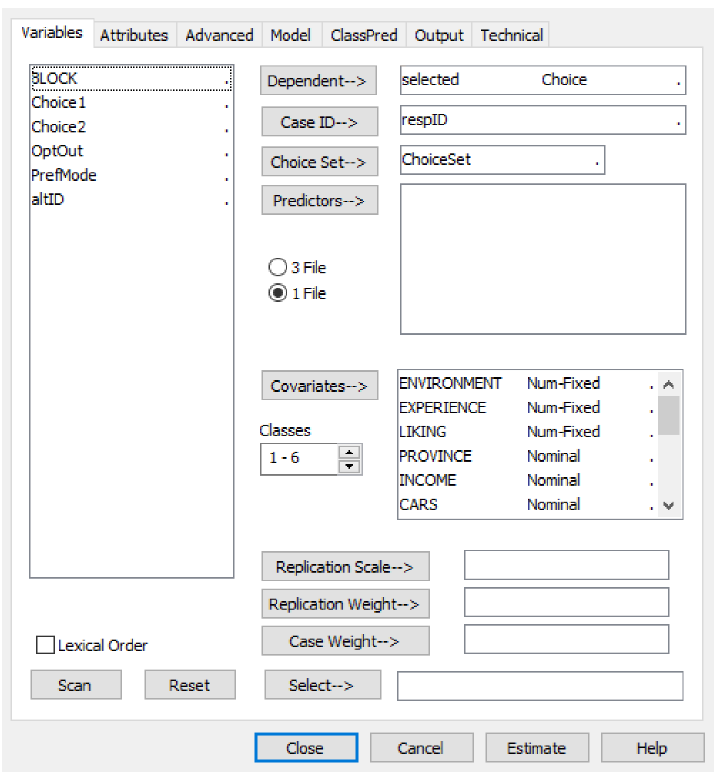
Personal liking of trains and traveling by trains	
Item	Cronbach's Alpha if item deleted
No	**0,785**
liking1	0,731
liking2	0,708
liking3	0,750
liking4	0,736

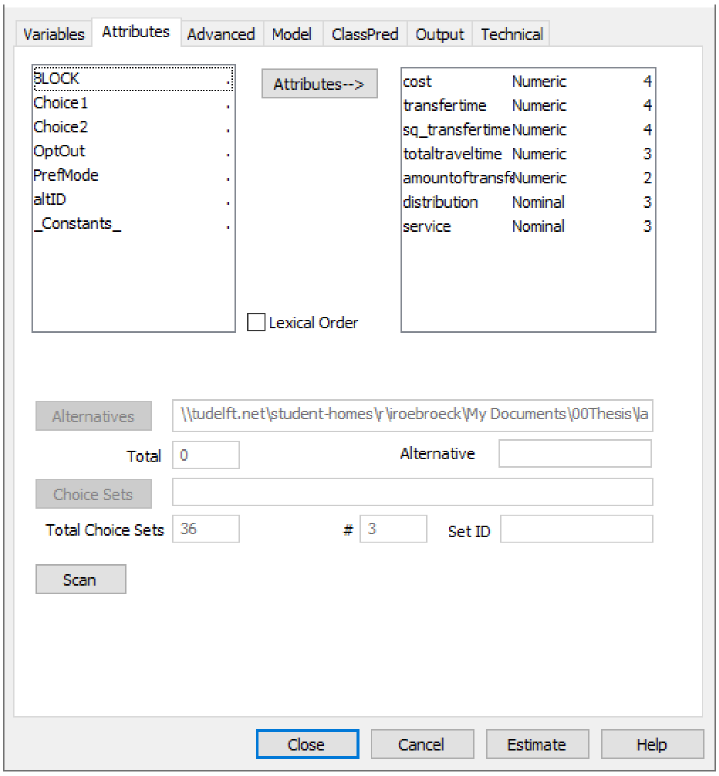
The value of Cronbach's Alpha denotes acceptable internal consistency when it is above 0.7, otherwise, it is questionable, and it becomes unacceptable below 0.5. The factors for Environmental considerations and Personal liking of trains and train travel are reliable as their Cronbach's Alpha is above 0.7. The reliability of the Environmental considerations factor could even be improved a little bit by deleting the third item, which is not surprising when you see that this item also has a much lower factor in the pattern matrix (figure 5.2). This is the item associated with the statement 'I believe that individual actions, like choosing environmentally friendly transportation, can make a difference in addressing climate change.' However, since it adds very little and the reliability is already very high, it was decided not to delete the item.

The Cronbach's Alpha of the factor for Bad experience with (long-distance) train travel is below the threshold of 0.7. Deleting items does not cause any positive effect. This means that although the value for experience3 in the pattern matrix was low, it does add to the unreliability of the factor. The fact that this factor has a questionable internal consistency does not mean it cannot be used, but it does mean that results regarding this factor should be interpreted cautiously, as it was not very accurately measured.

H

Latent GOLD setup

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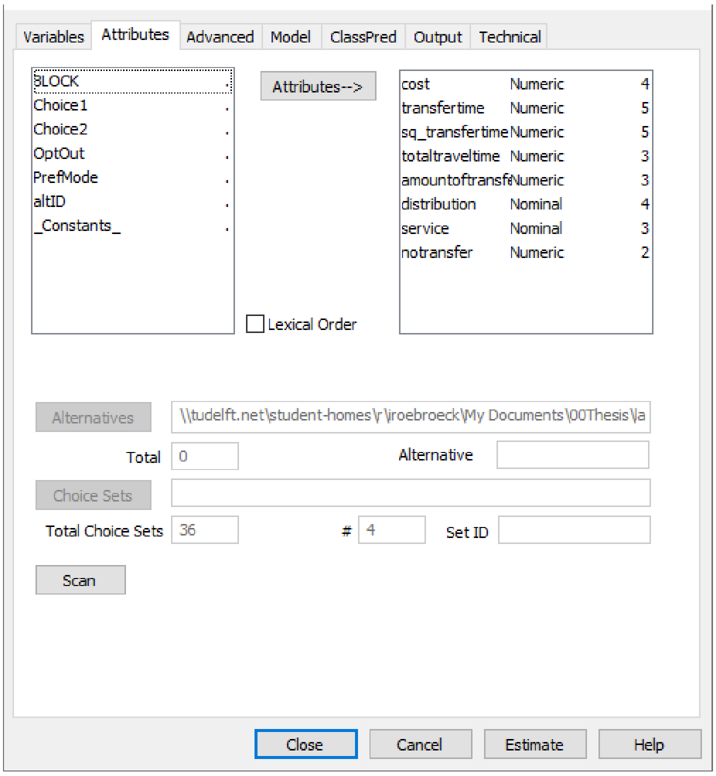
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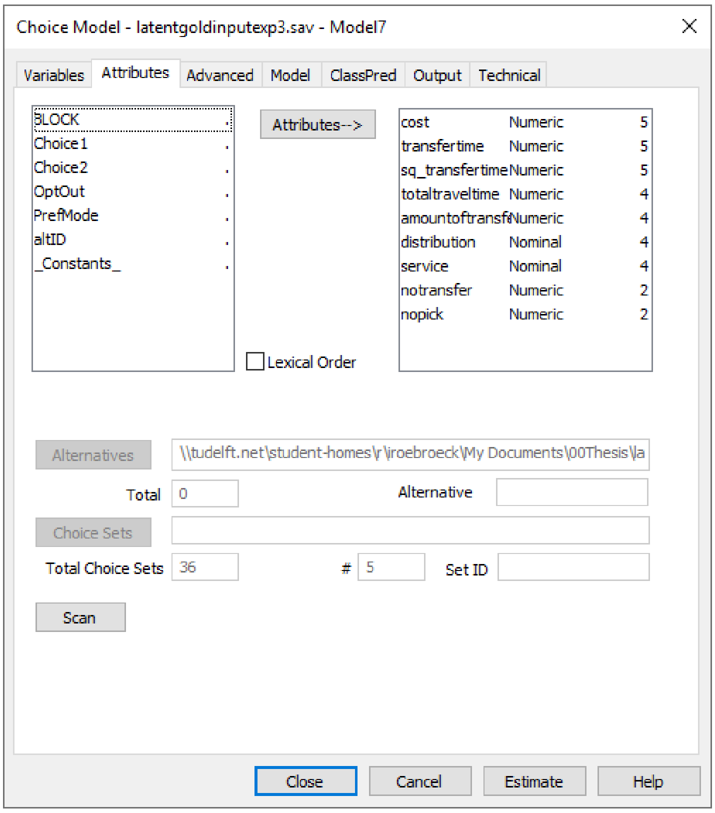
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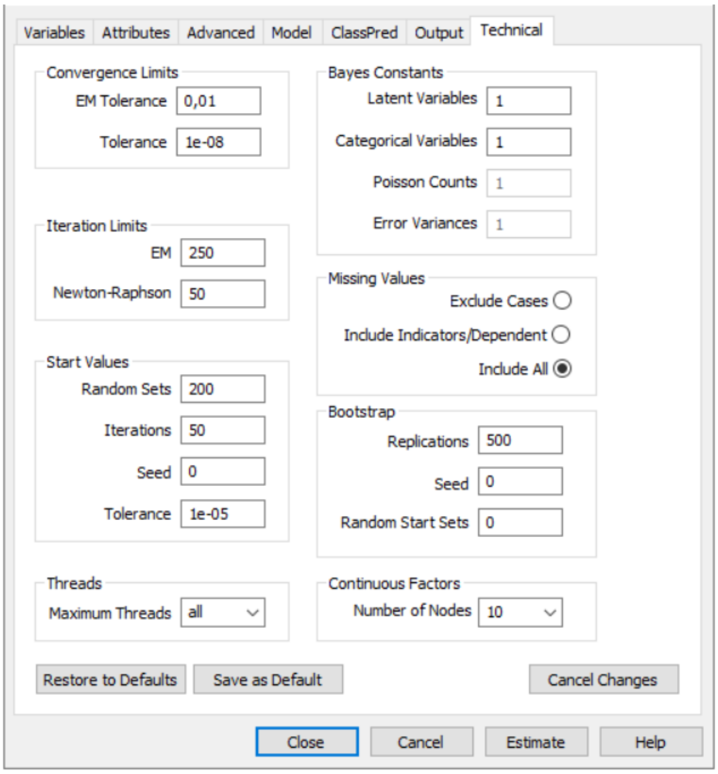
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Random Sets
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Iterations
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Seed
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Tolerance
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Threads
Maximum Threads
all
Bayes Constants
Latent Variables
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Categorical Variables
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Poisson Counts
1
Error Variances
1
Missing Values
Exclude Cases
Include Indicators/Dependent
Include All
Bootstrap
Replications
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Seed
0
Random Start Sets
0
Continuous Factors
Number of Nodes
10
Restore to Defaults
Save as Default
Cancel Changes
Close
Cancel
Estimate
Help